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(54) **IMPEDANCE-BASED VERIFICATION FOR DELIVERY OF IMPLANTABLE MEDICAL DEVICES**

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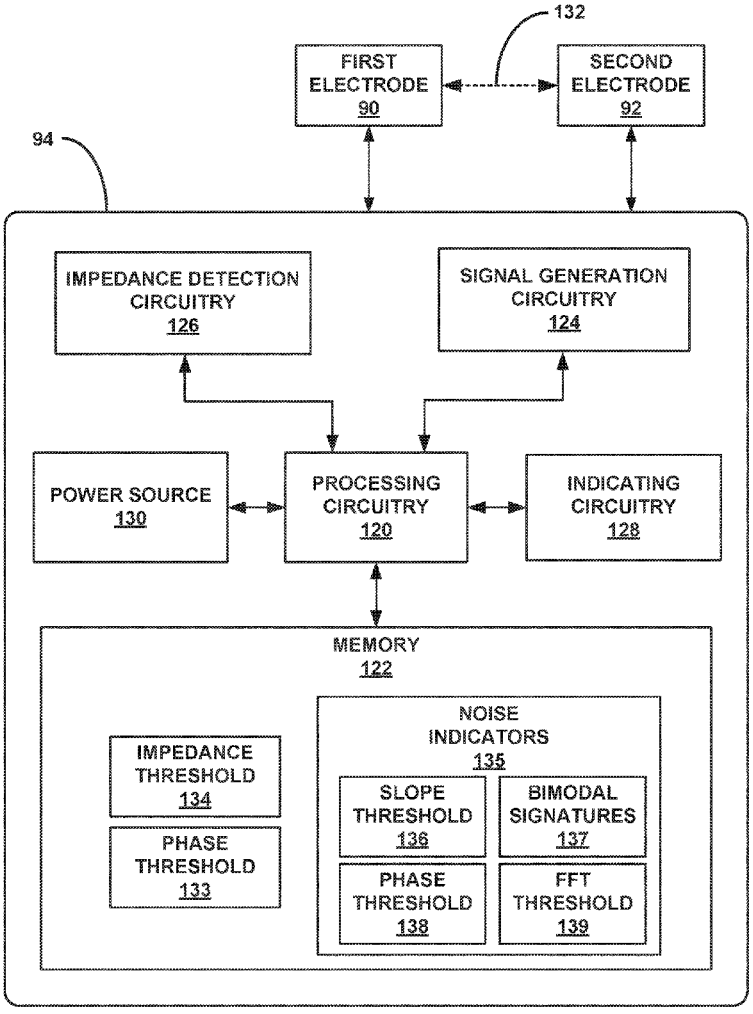
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A61N 1/08	(2006.01)

(52) **U.S. Cl.**

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(57) **ABSTRACT**

A device for delivering an implantable medical device (IMD) includes an elongated member and a deployment bay configured to house the IMD, the deployment bay defining a distal opening for deploying the IMD out of the deployment bay. The device includes a first electrode located inside the deployment bay during intravascular navigation, a second electrode, and impedance detection circuitry configured to deliver an electrical signal to a path between the first electrode and the second electrode through at least one of a fluid or tissue of the patient. The device also includes processing circuitry configured to determine an impedance of the path based on the signal and control a user interface to indicate when an impedance of the path indicates that at least one of the IMD or the distal opening is in a fixation configuration relative to the target site of the patient.



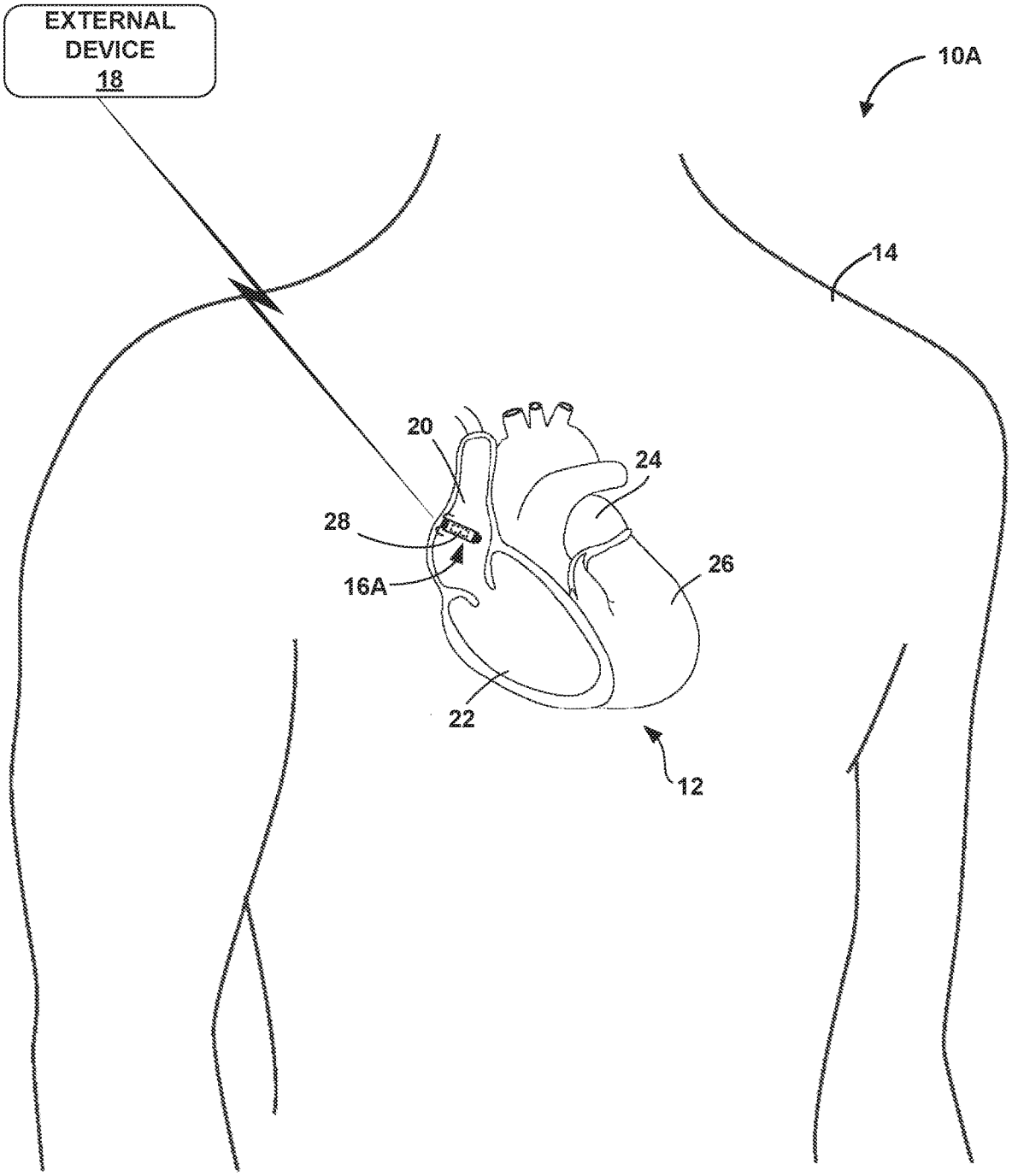


FIG. 1A

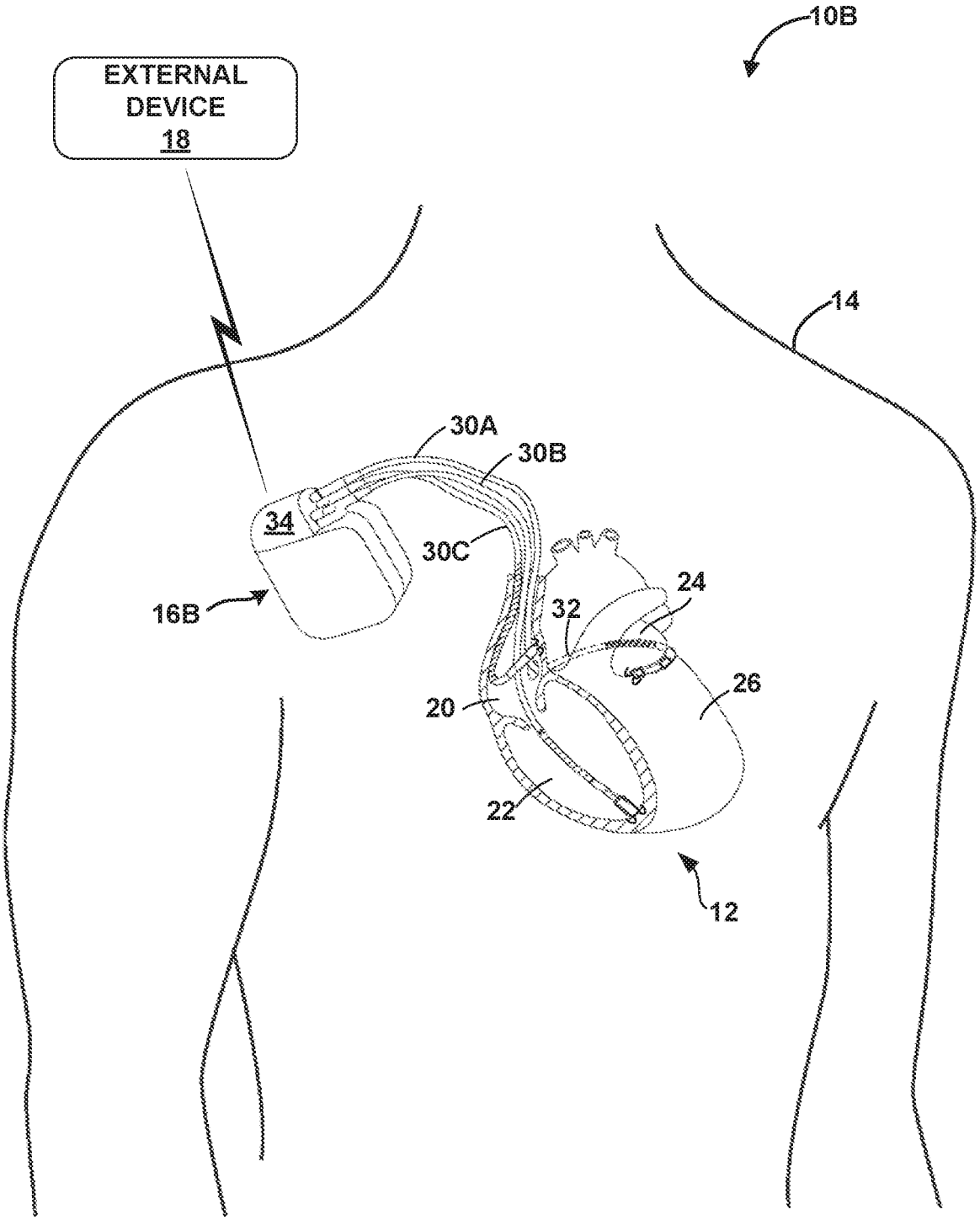


FIG. 1B

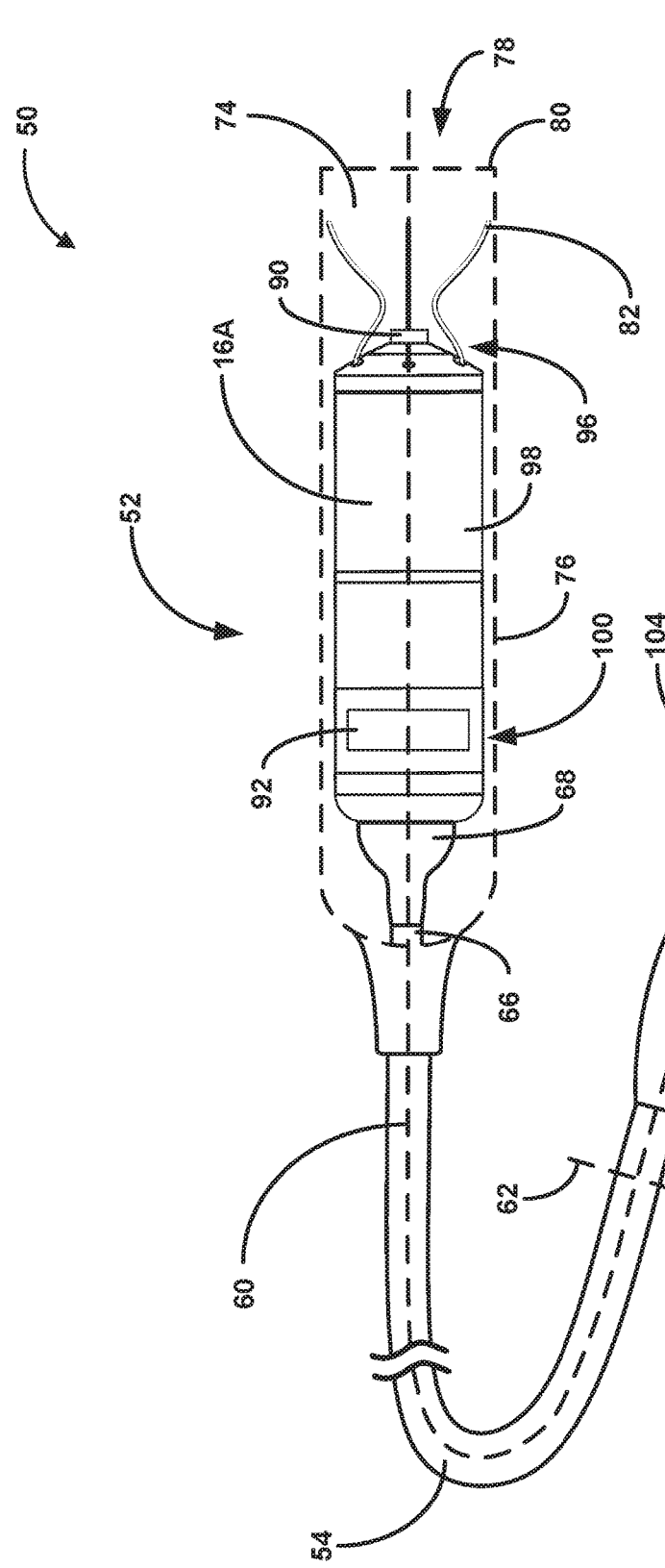

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52
54
56
58
60
62
64
66
68
70
72
74
76
78
80
82
90
92
94
96
98
100
102A
102B
104
16A

FIG. 2A

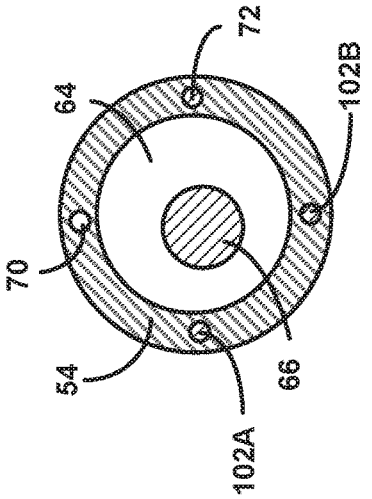

64
72
102B
70
54
66
102A

FIG. 2B

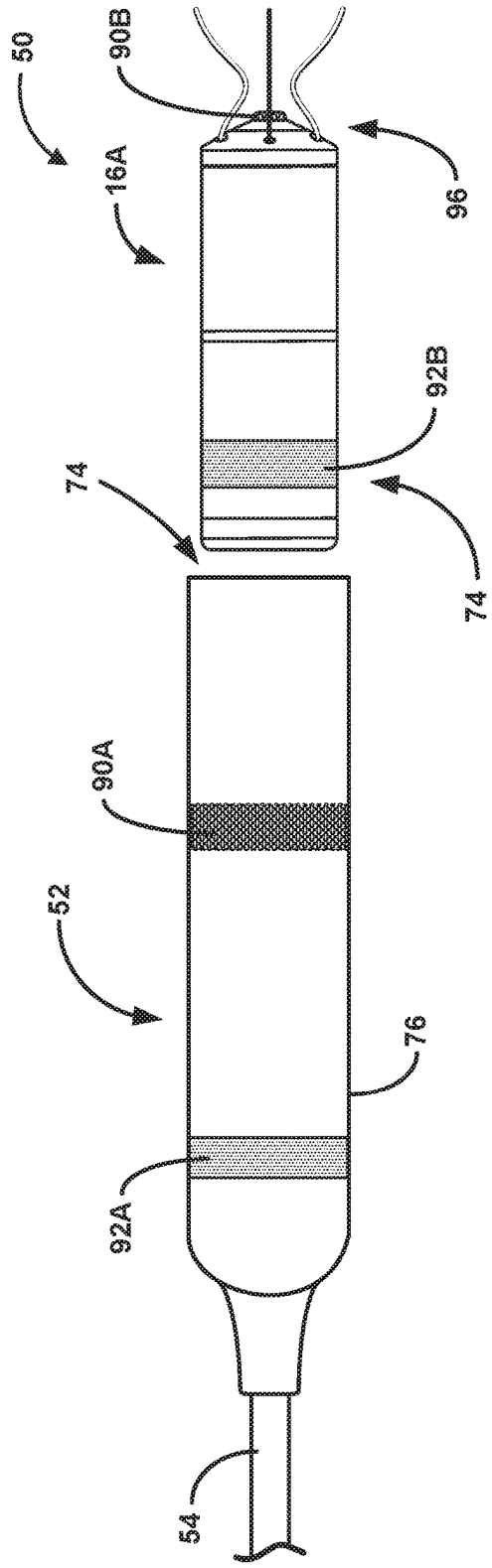

50
90B
16A
96
92B
74
74
90A
52
76
92A
54

FIG. 2C

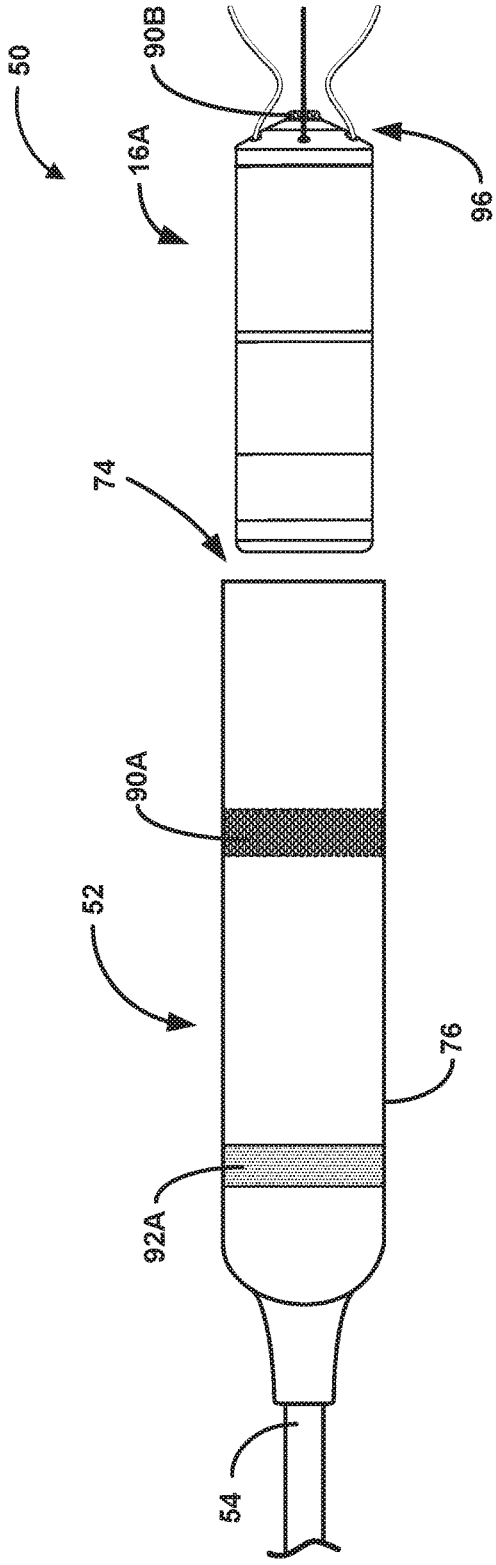

50
90B
16A
96
74
90A
52
76
92A
54

FIG. 2D

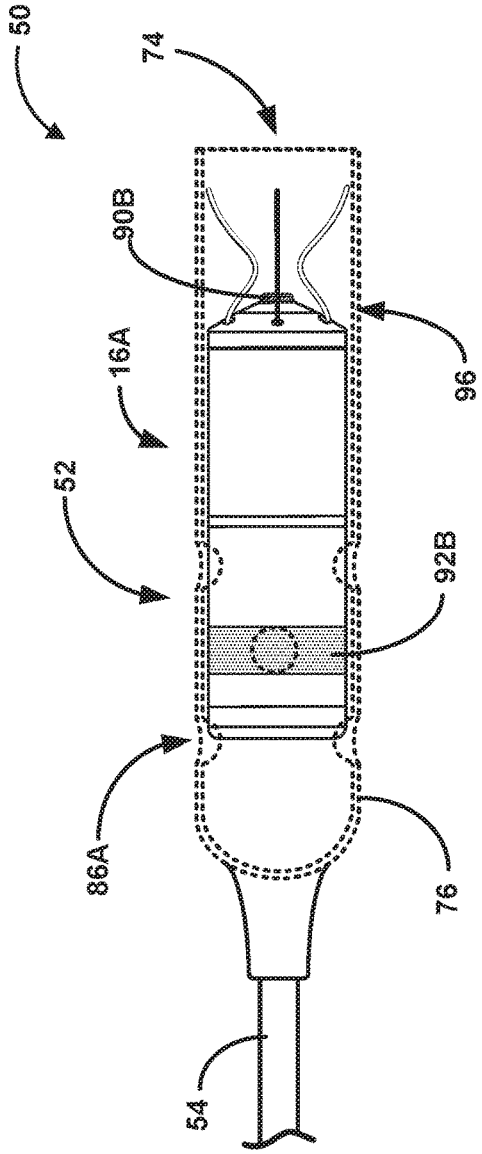


FIG. 2E

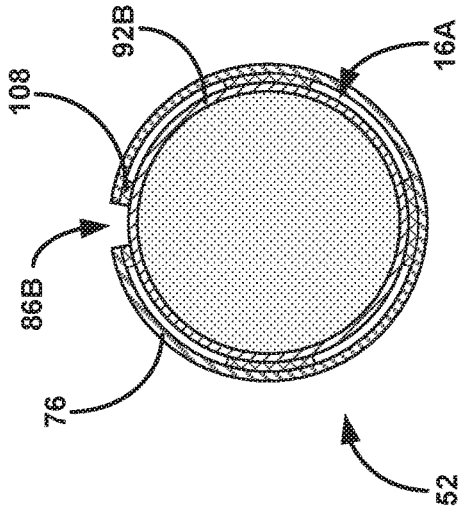


FIG. 2G

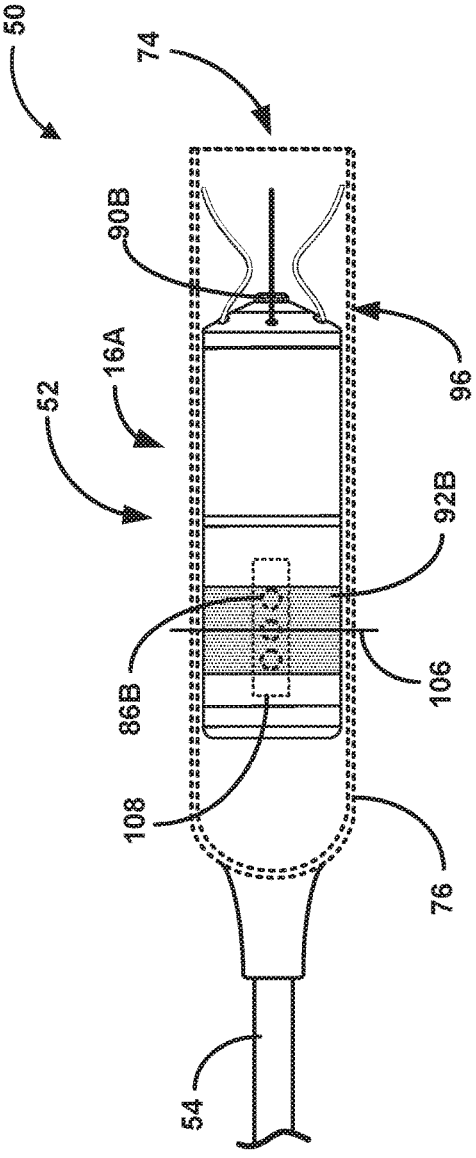


FIG. 2F

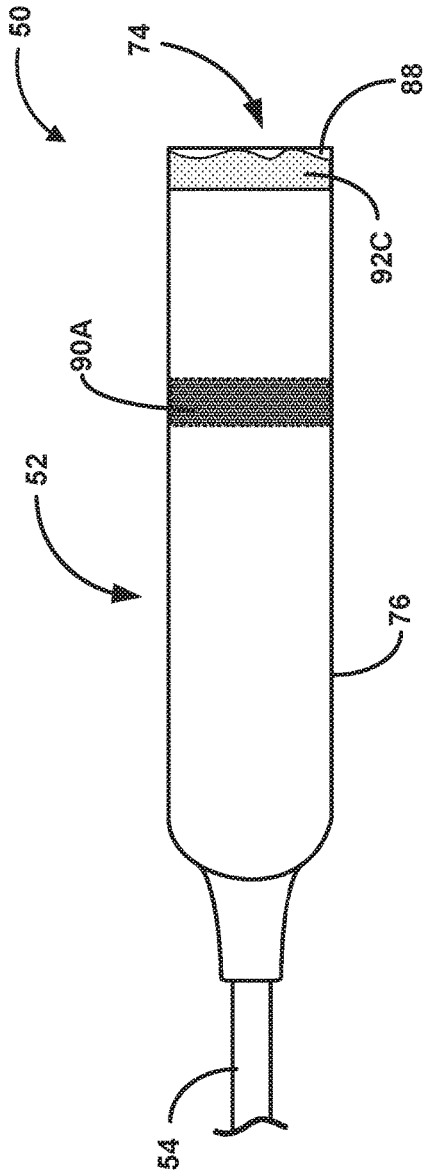

50
74
88
92C
90A
52
76
54

FIG. 2H

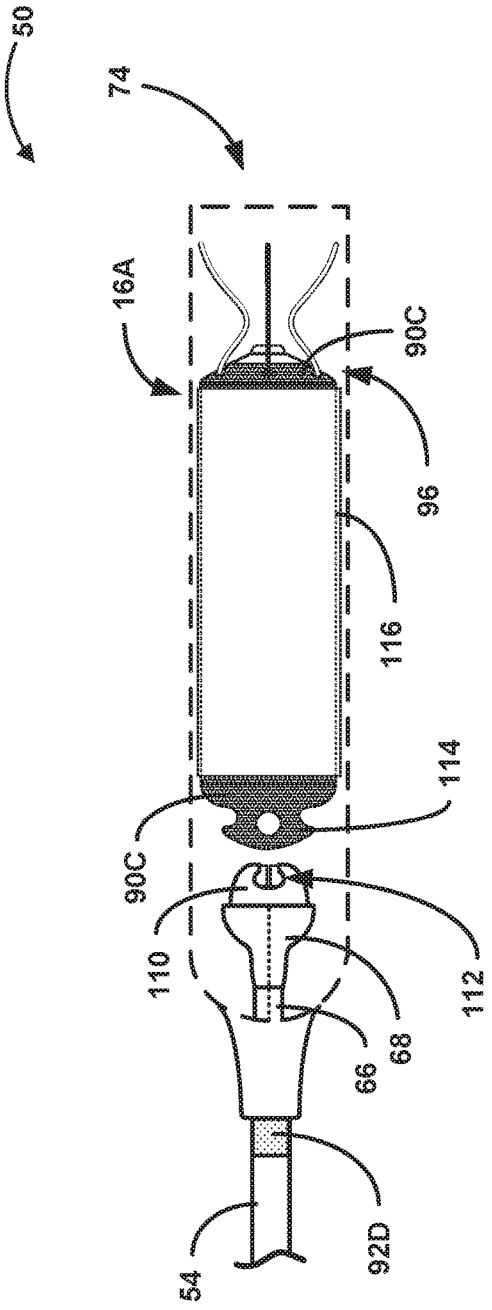

50
74
16A
90C
96
116
114
90C
110
112
66
68
54
92D

FIG. 2I

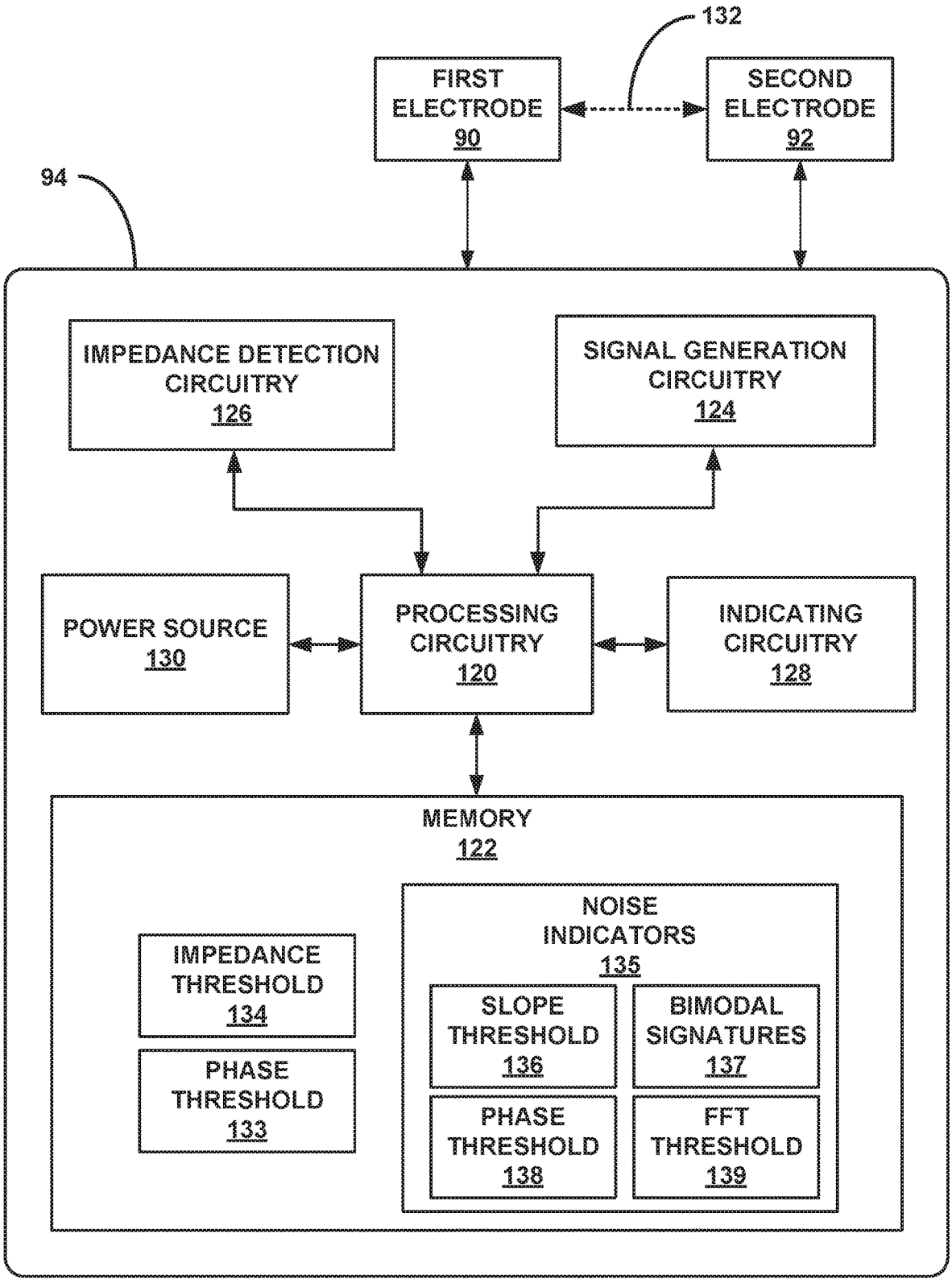

132
FIRST ELECTRODE 90
SECOND ELECTRODE 92
94
IMPEDANCE DETECTION CIRCUITRY 126
SIGNAL GENERATION CIRCUITRY 124
POWER SOURCE 130
PROCESSING CIRCUITRY 120
INDICATING CIRCUITRY 128
MEMORY 122
IMPEDANCE THRESHOLD 134
PHASE THRESHOLD 133
NOISE INDICATORS 135
SLOPE THRESHOLD 136
BIMODAL SIGNATURES 137
PHASE THRESHOLD 138
FFT THRESHOLD 139

FIG. 3

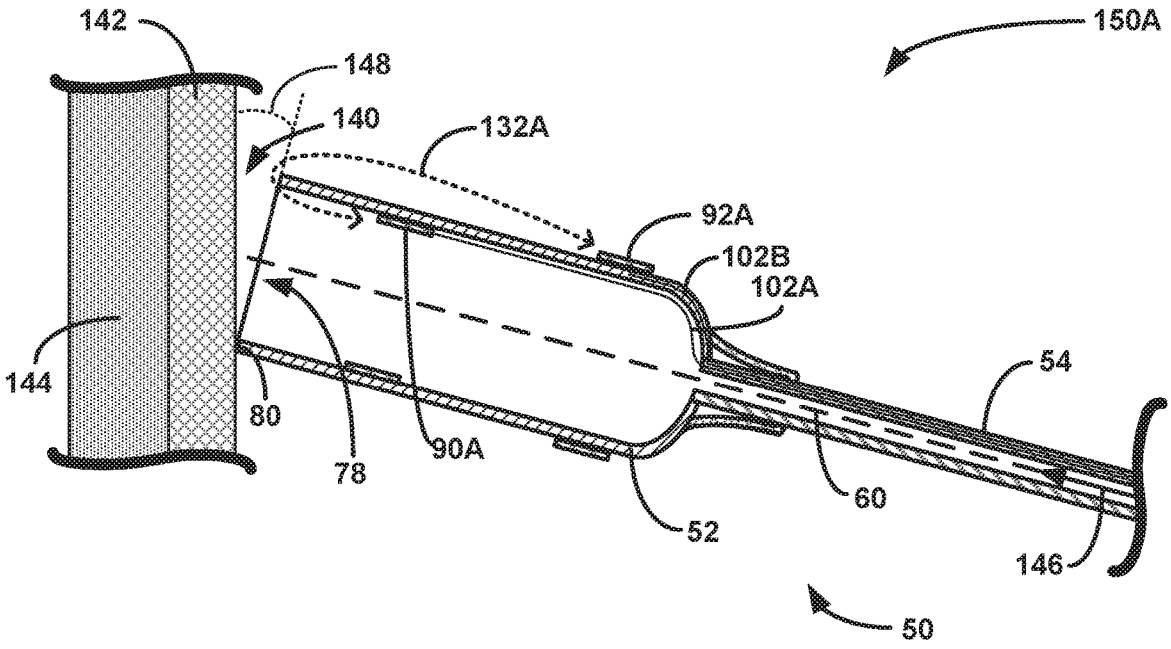

142
148
140
132A
150A
92A
102B
102A
144
80
78
90A
54
60
52
146
50

FIG. 4A

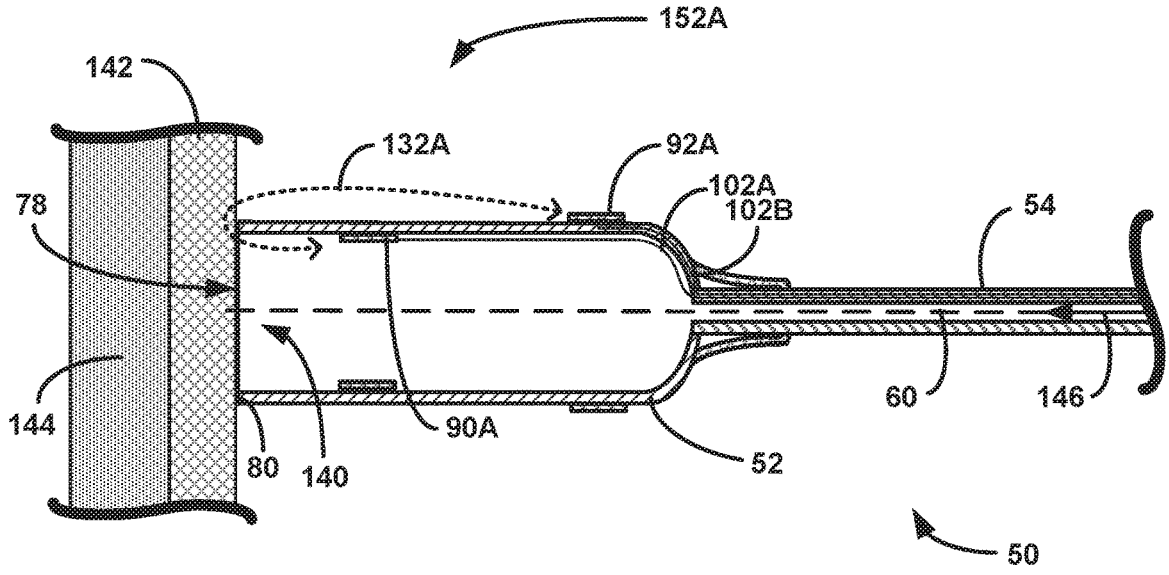

152A
142
132A
92A
102A
102B
78
54
144
60
146
90A
80
140
52
50

FIG. 4B

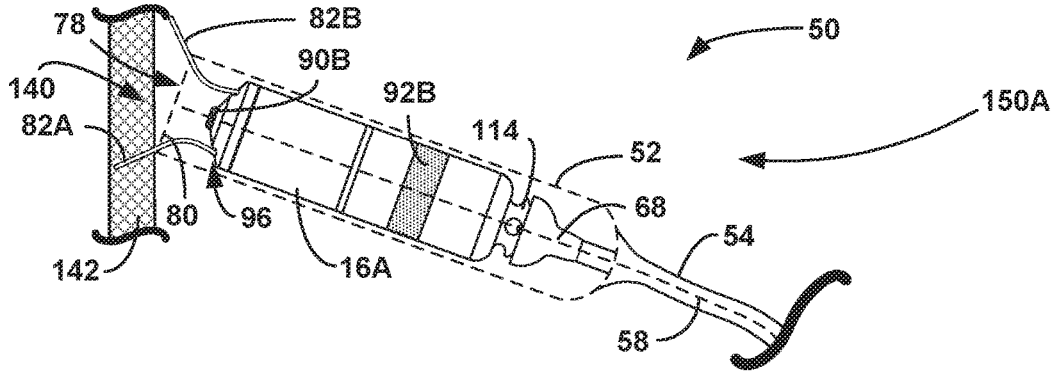


FIG. 5A

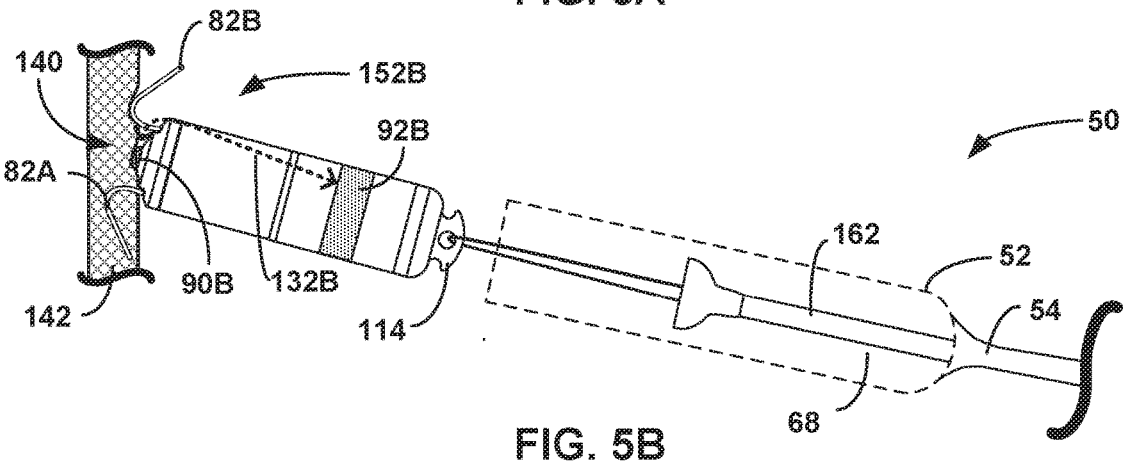


FIG. 5B

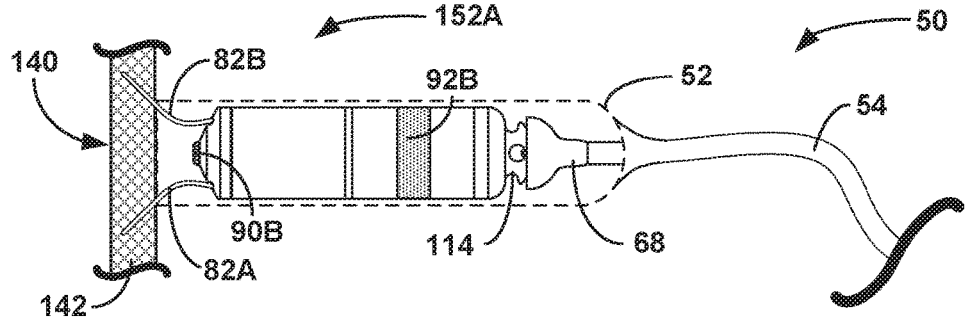


FIG. 5C

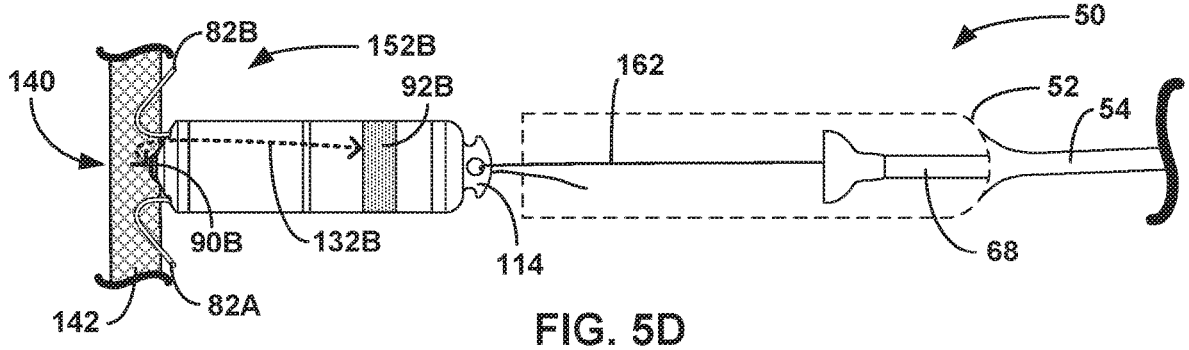


FIG. 5D

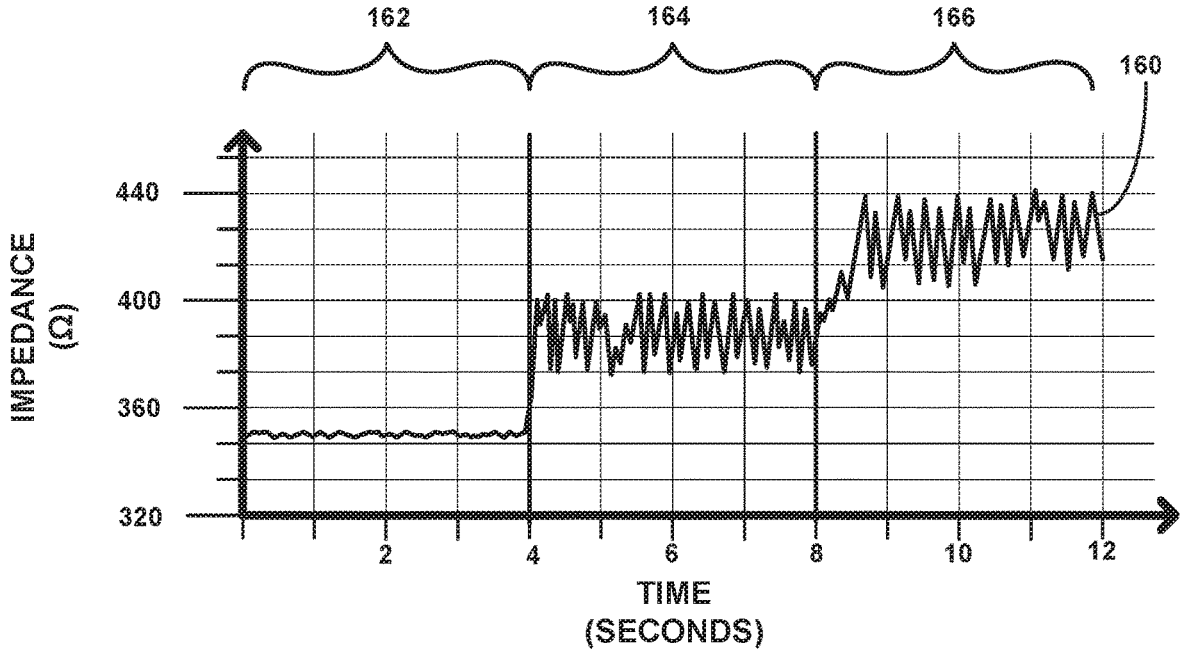

162
164
166
160
IMPEDANCE (Ω)
440
400
360
320
2
4
6
8
10
12
TIME (SECONDS)

FIG. 6

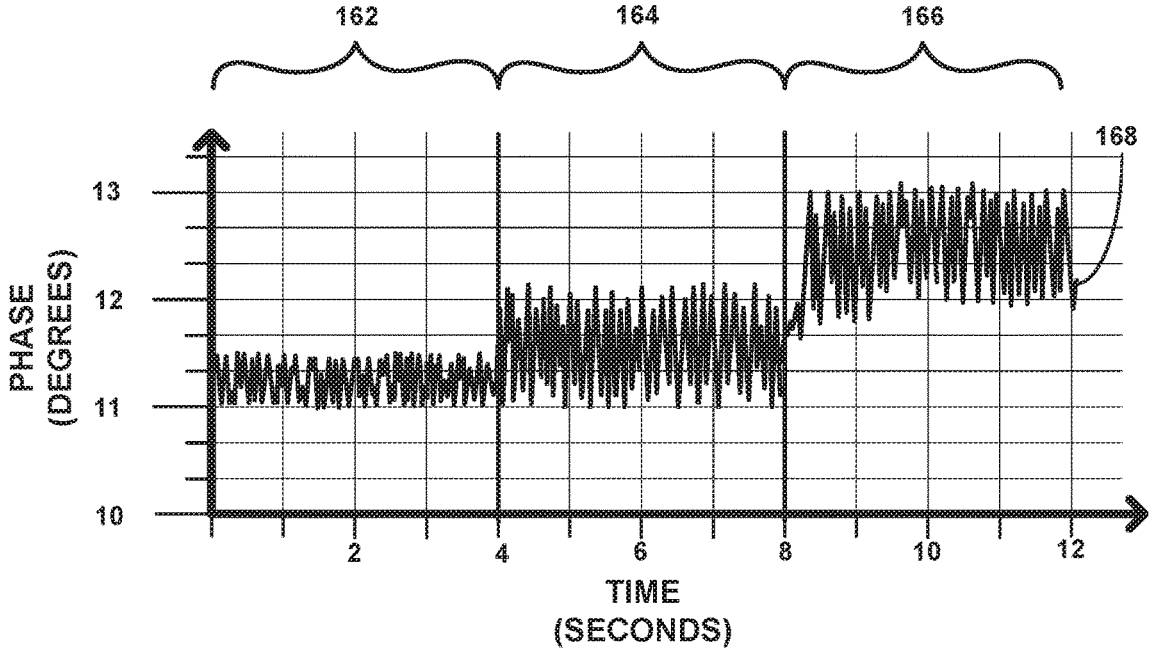

162
164
166
168
PHASE (DEGREES)
13
12
11
10
2
4
6
8
10
12
TIME (SECONDS)

FIG. 7

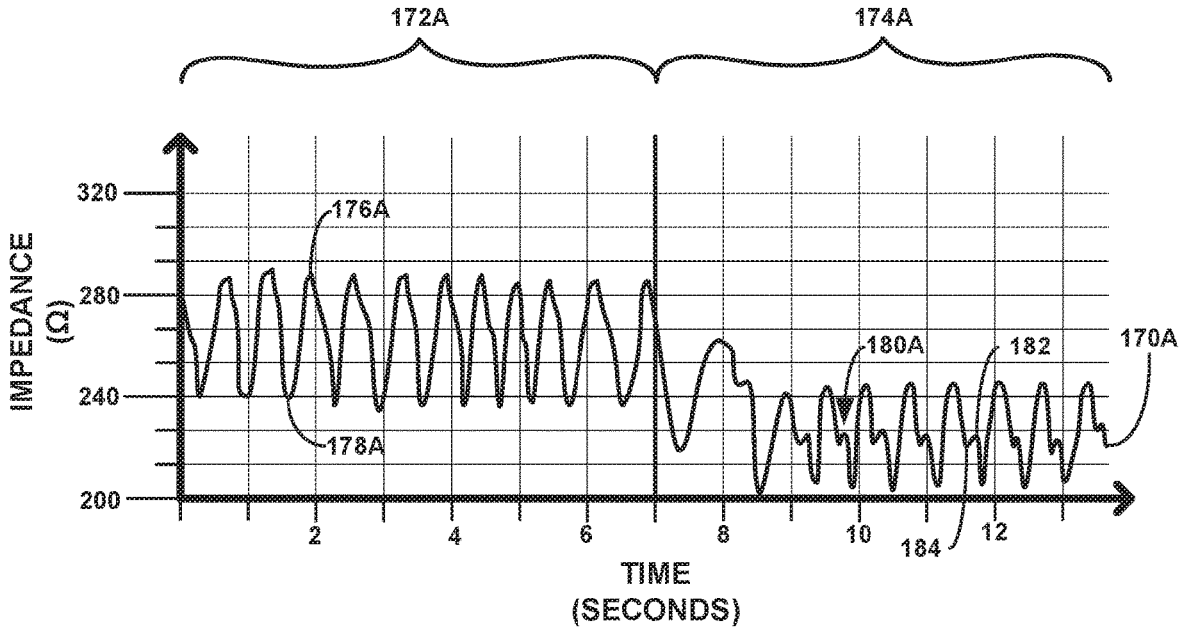

172A
174A
320
280
240
200
IMPEDANCE (Ω)
176A
178A
180A
182
170A
184
2
4
6
8
10
12
TIME (SECONDS)

FIG. 8A

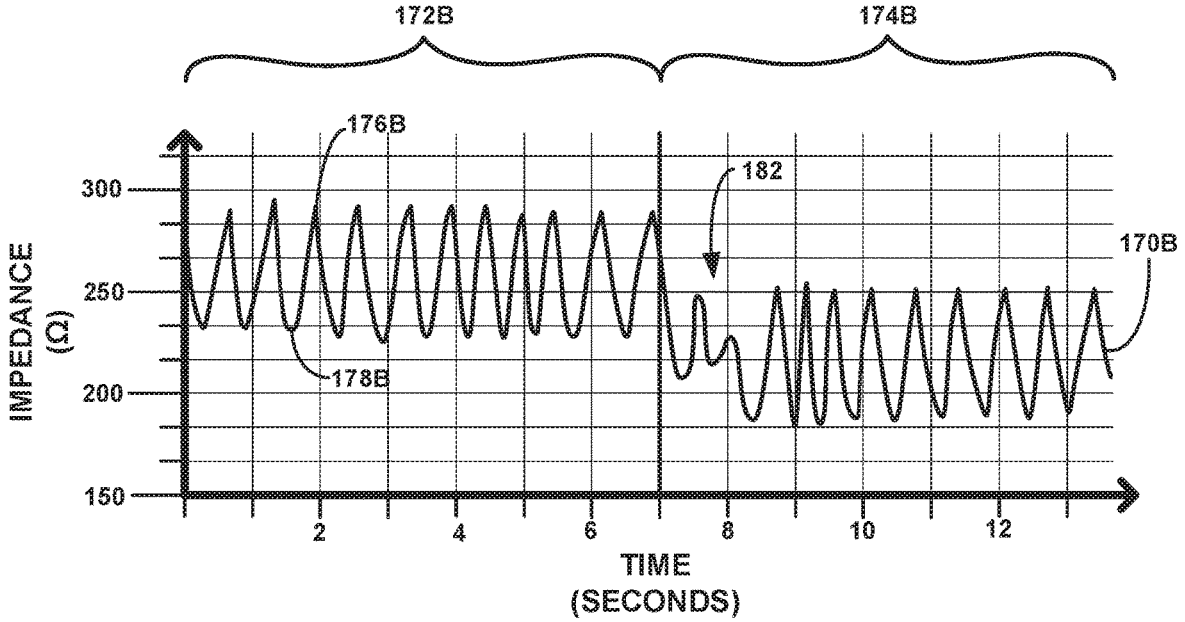

172B
174B
300
250
200
150
IMPEDANCE (Ω)
176B
178B
182
170B
2
4
6
8
10
12
TIME (SECONDS)

FIG. 8B

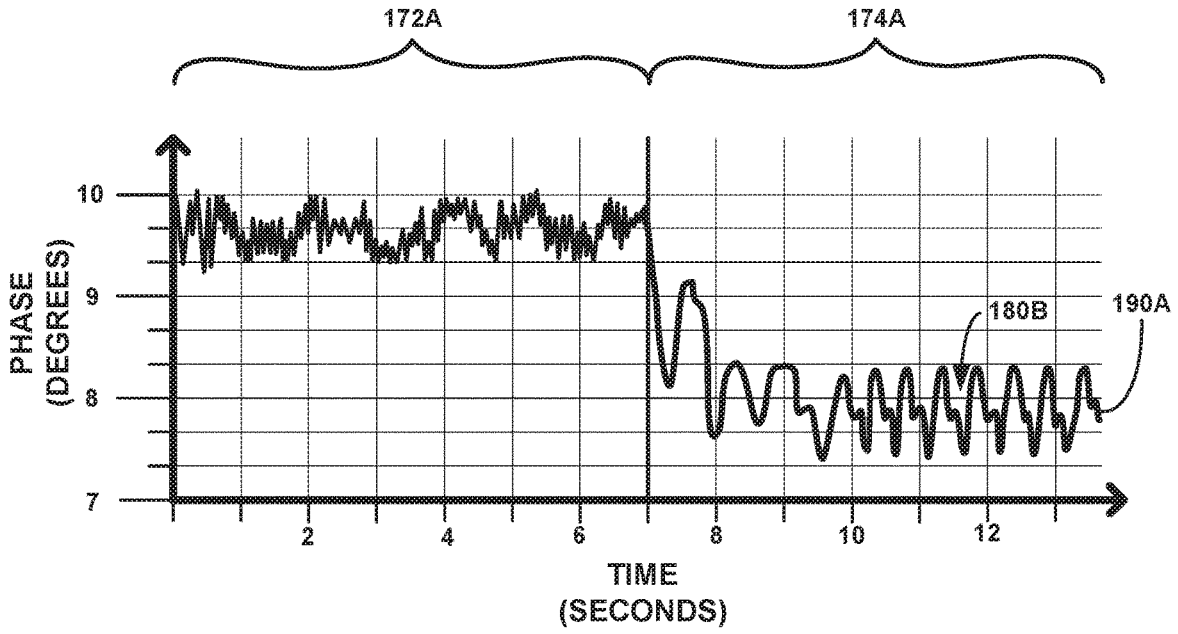

172A
174A
PHASE (DEGREES)
10
9
8
7
2
4
6
8
10
12
TIME (SECONDS)
180B
190A

FIG. 9A

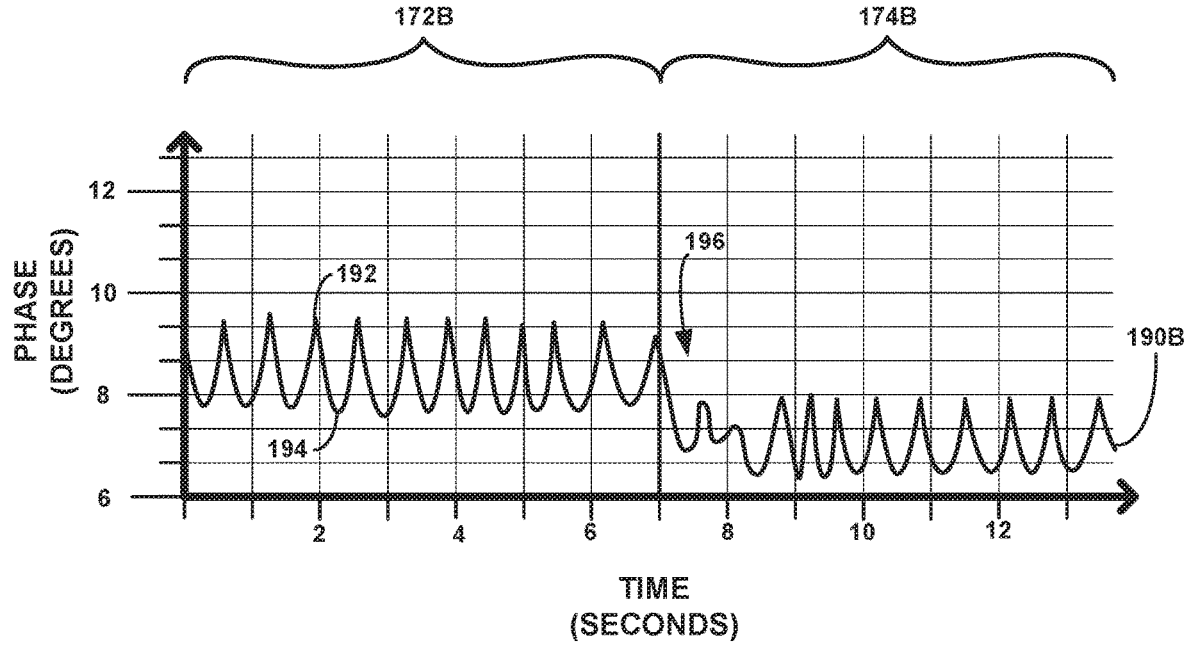

172B
174B
PHASE (DEGREES)
12
10
8
6
2
4
6
8
10
12
TIME (SECONDS)
192
194
196
190B

FIG. 9B

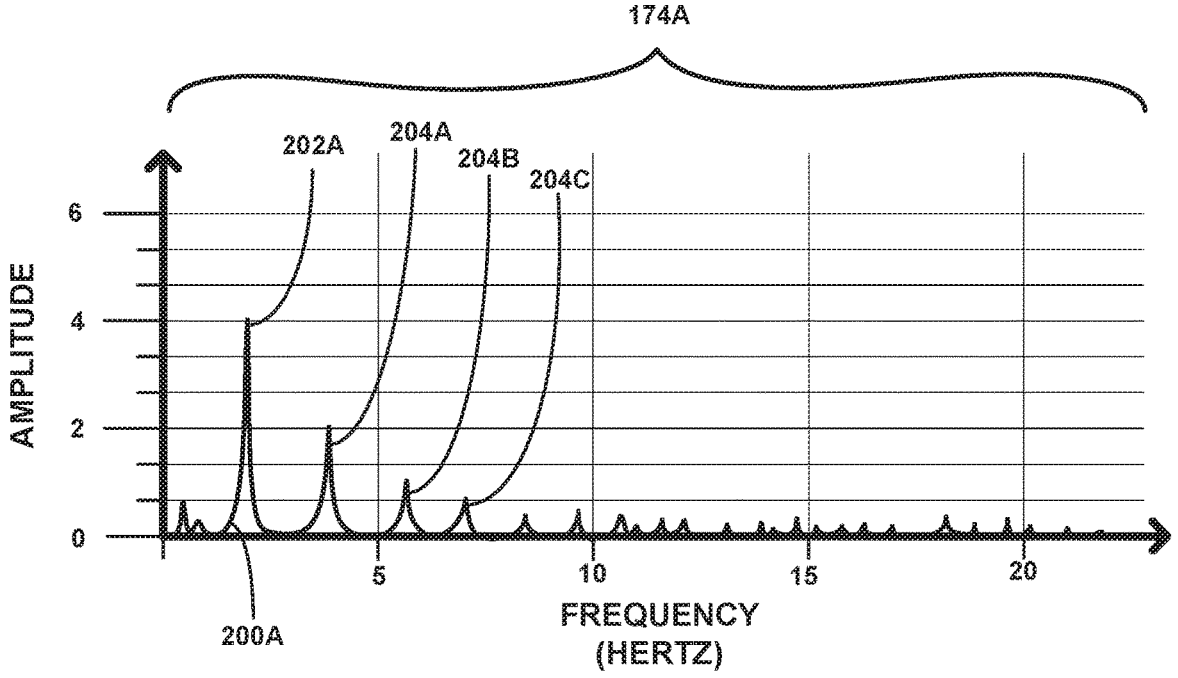


FIG. 10A

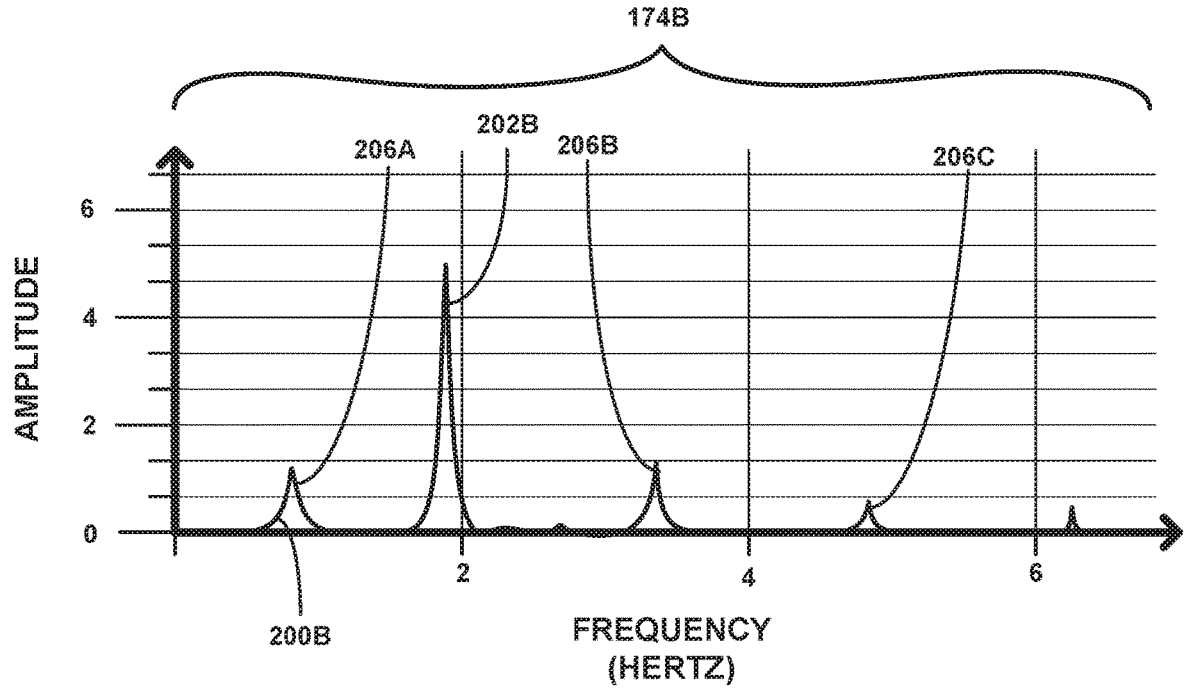


FIG. 10B

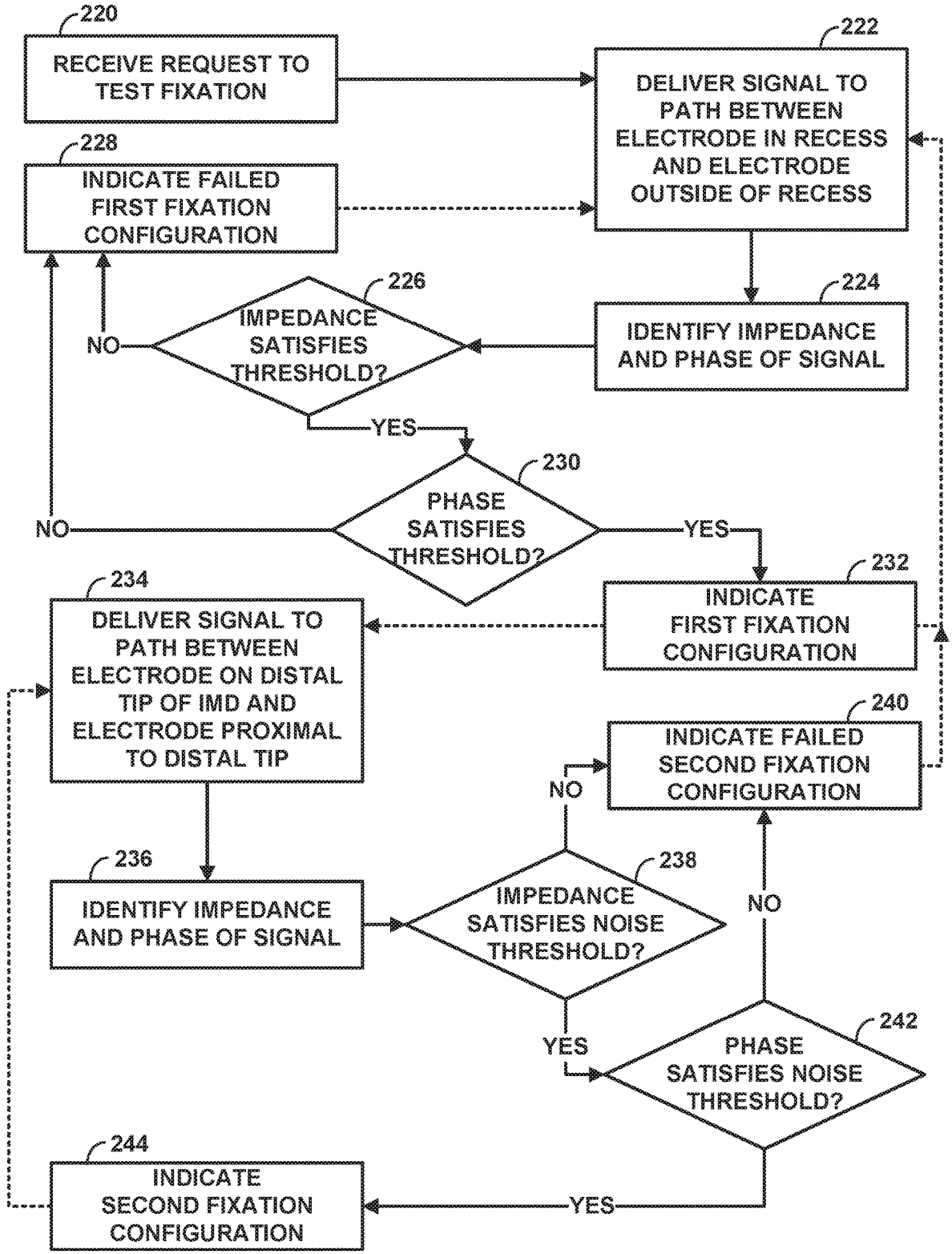

220
RECEIVE REQUEST TO TEST FIXATION
222
DELIVER SIGNAL TO PATH BETWEEN ELECTRODE IN RECESS AND ELECTRODE OUTSIDE OF RECESS
228
INDICATE FAILED FIRST FIXATION CONFIGURATION
226
IMPEDANCE SATISFIES THRESHOLD?
NO
224
IDENTIFY IMPEDANCE AND PHASE OF SIGNAL
YES
230
PHASE SATISFIES THRESHOLD?
NO
YES
232
INDICATE FIRST FIXATION CONFIGURATION
234
DELIVER SIGNAL TO PATH BETWEEN ELECTRODE ON DISTAL TIP OF IMD AND ELECTRODE PROXIMAL TO DISTAL TIP
240
INDICATE FAILED SECOND FIXATION CONFIGURATION
NO
236
IDENTIFY IMPEDANCE AND PHASE OF SIGNAL
238
IMPEDANCE SATISFIES NOISE THRESHOLD?
NO
YES
242
PHASE SATISFIES NOISE THRESHOLD?
244
INDICATE SECOND FIXATION CONFIGURATION
YES

FIG. 11

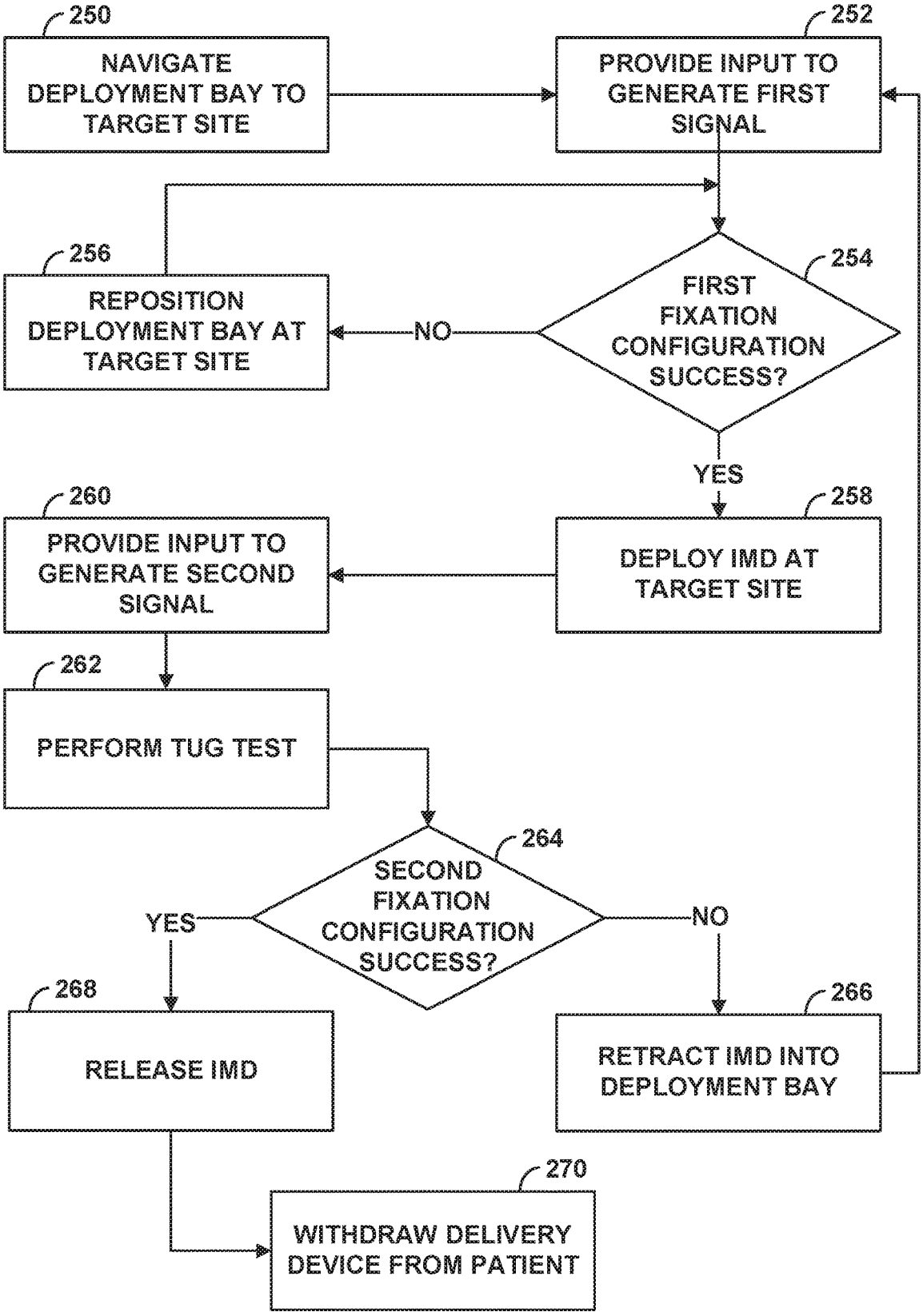

250
NAVIGATE DEPLOYMENT BAY TO TARGET SITE
252
PROVIDE INPUT TO GENERATE FIRST SIGNAL
254
FIRST FIXATION CONFIGURATION SUCCESS?
NO
256
REPOSITION DEPLOYMENT BAY AT TARGET SITE
YES
258
DEPLOY IMD AT TARGET SITE
260
PROVIDE INPUT TO GENERATE SECOND SIGNAL
262
PERFORM TUG TEST
264
SECOND FIXATION CONFIGURATION SUCCESS?
YES
NO
266
RETRACT IMD INTO DEPLOYMENT BAY
268
RELEASE IMD
270
WITHDRAW DELIVERY DEVICE FROM PATIENT

FIG. 12

IMPEDANCE-BASED VERIFICATION FOR DELIVERY OF IMPLANTABLE MEDICAL DEVICES

TECHNICAL FIELD

[0001] The disclosure generally relates to medical delivery devices that are configured to deliver implantable and/or insertable medical devices to a target site within a human body.

BACKGROUND

[0002] A variety of medical devices for delivering a therapy and/or monitoring a physiological condition have been used clinically or proposed for clinical use in patients. Examples include medical devices that deliver therapy to and/or monitor conditions associated with the heart, muscles, nerves, brain, stomach or other organs or tissue or a patient. Some medical devices may employ one or more electrodes for the delivery of therapeutic electrical signals to such organs or tissues and/or one or more electrodes for sensing intrinsic electrical signals within the patient that are generated by such organs or tissue. Similarly, some medical devices may additionally or alternatively include one or more other sensors for sensing physiological parameters of a patient.

[0003] For example, some medical devices may function as cardiac pacemakers or cardioverter-defibrillators that provide therapeutic electrical signals to the heart. The therapeutic electrical signals may include pulses for pacing, or shocks for cardioversion or defibrillation. In some examples, a medical device may sense intrinsic depolarizations of the heart and thereby control delivery of therapeutic signals to the heart based on the sensed depolarizations. Upon detection of an abnormal rhythm, such as bradycardia, tachycardia, or fibrillation, an appropriate therapeutic electrical signal or signals may be delivered to restore or maintain a predetermined (e.g., relatively more normal) rhythm. For example, in some cases, an implanted medical device may deliver pacing stimulation to the heart of the patient upon detecting tachycardia or bradycardia, and/or deliver cardioversion or defibrillation shocks to the heart upon detecting fibrillation.

[0004] In some examples a medical device may utilize one or more medical leads with one or more electrodes or other sensors for delivery of therapeutic electrical signals or sensing. For example, electrodes or sensors may be carried at a distal portion of a lead, where, a proximal portion of the lead may be coupled to a medical device housing that contains circuitry such as signal generation and/or sensing circuitry. Alternatively, an implanted medical device may function without a lead, such that the implantable medical device includes one or more electrodes on its outer housing to deliver therapeutic electrical signals to patient, and/or sense intrinsic electrical signals of patient. For example, leadless cardiac devices, such as leadless pacemakers, may sense intrinsic depolarizations and/or other physiological parameters of the heart and/or deliver therapeutic electrical signals to the heart. Leadless cardiac devices may be positioned within or outside of the heart and, in some examples, may be anchored to a wall of the heart via a fixation mechanism. Leadless cardiac devices may be delivered to the heart percutaneously and/or transvascularly using a device that includes a catheter.

SUMMARY

[0005] Aspects of the disclosure are directed to methods and structures related to delivery devices for delivering implantable medical devices (IMDs) that are configured to verify that the delivery device and/or IMD are defining one or more fixation configurations relative to a target site of the patient. Fixation configurations may include spatial arrangements of the delivery device, IMD, and/or tissue of the target site that are indicative of efficacious fixation of the IMD to the target site. The fixation configurations may include a first fixation configuration that is tested (and potentially defined and therein verified) prior to deployment (and fixation) of the IMD to the target site. The first fixation configuration may include a spatial relationship of the delivery device relative to the tissue of the target site, wherein the spatial relationship is conducive to fixation elements of the IMD achieving desired fixation to the target site. For example, the first fixation configuration may relate to a delivery device orienting a deployment port in a predetermined manner relative to a surface of the target site. Additionally, or alternatively, the fixation configurations may include a second fixation configuration that is tested (and potentially defined and therein verified) subsequent to deployment and fixation of the IMD that relates to the IMD achieving a threshold amount of fixation. For example, the threshold amount of fixation may relate to a threshold number of fixation elements being fixated to tissue of the target site, therein causing a component (e.g., an electrode) of the IMD to achieve a threshold level of contact against the target site, or the threshold amount of fixation may relate to a threshold number of turns of a single distal screw being inserted into tissue of the target site.

[0006] The system may verify these fixation configurations by providing an electrical signal to fluid and/or tissue of a patient at the target site between two electrodes and then identifying and analyzing an impedance of this electrical signal as provided. For example, prior to deployment of the IMD, the system may send an electrical signal to fluid and/or tissue in an electrical path between a first electrode that is located inside of the deployment bay that houses the IMD and a second electrode that is located outside of the deployment bay. The system may then identify an impedance of the signal between these two electrodes. The system may be configured to identify that the delivery device defines the first fixation configuration when an impedance of this signal rises above a predetermined threshold (e.g., as a result of the electrical signal defining a path through tissue which has a higher resistance, indicating that the delivery port is adequately pressed against tissue of the target site). Similarly, the system may be configured to identify that the IMD defines the second fixation configuration when an impedance of this signal is stable, such as stable during a tug test (where the IMD is tugged lightly after the fixation elements have been supposedly secured to the target site). For example, the system may be configured to identify when the impedance of the signal picks up some harmonics such as a bimodal signature or relatively "noisy" slopes when the IMD is not in the second fixation configuration. Additionally, or alternatively, the system may identify an amount of lag between the voltage and the current (e.g., an amount that the voltage leads/lags the current) across the electrodes to identify phase waveform of the impedance electrical signal (s), and therein determine that the deployment bay and/or IMD define a first or second fixation configuration depend-

ing upon if the phase waveform is noisy or clean. Further, the system may be configured to execute fast Fourier transform (FFT) algorithms on the impedance signal to isolate frequency components that may indicate whether the deployment bay or IMD define fixation configurations. The system may then identify for the clinician if and whether the delivery device and/or IMD define the first, second, or neither fixation configuration.

[0007] In some examples, an implantable medical device delivery system includes an elongated member configured to navigate an intravascular system of a patient. The delivery system also includes a deployment bay connected to a distal portion of the elongated member and configured to house at least a portion of an implantable medical device (IMD). The deployment bay defines a distal opening configured for deployment of the IMD out of the deployment bay at a target site in a patient. The delivery system also includes a first electrode located inside of the deployment bay as the elongated member navigates the intravascular system. The delivery system also includes a second electrode. The delivery system also includes signal generation circuitry configured to deliver an electrical signal to a path between the first electrode and the second electrode through at least one of a fluid or tissue of the patient. The delivery system also includes processing circuitry configured to determine an impedance of the path based on the signal and control a user interface to indicate when an impedance of the path indicates that at least one of the IMD or the distal opening is in a fixation configuration relative to the target site of the patient.

[0008] In other examples, an implantable medical device delivery system includes an elongated member configured to navigate an intravascular system of a patient. The delivery system also includes a deployment bay connected to a distal portion of the elongated member and configured to house at least a portion of an implantable medical device (IMD). The deployment bay defines a distal opening configured for deployment of the IMD out of the deployment bay at a target site in a patient. The delivery system also includes a first electrode secured to an inner surface of the deployment bay. The delivery system also includes a second electrode secured to an outer surface of either the deployment bay or the elongated member. The delivery system also includes signal generation circuitry configured to deliver an electrical signal to a path between the first electrode and the second electrode through at least one of a fluid or tissue of the patient. The delivery system also includes processing circuitry configured to determine an impedance of the path based on the signal and control a user interface to indicate when an impedance of the path indicates that the distal opening is in a fixation configuration relative to the target site of the patient.

[0009] In other examples, an implantable medical device delivery system includes an implantable medical device (IMD) configured to be secured to a target site in a patient via a plurality of fixation elements extending distally from a distal tip of a housing of the IMD. The delivery system also includes a first electrode secured to the distal tip of the housing. The delivery system also includes a second electrode secured to an outer surface of a proximal portion of the housing. The delivery system also includes signal generation circuitry configured to deliver an electrical signal to a path between the first electrode and the second electrode through at least one of a fluid or tissue of the patient. The delivery system also includes processing circuitry configured to determine an impedance of the path based on the signal and control a user interface to indicate when an impedance of the path indicates that the IMD is in a fixation configuration relative to the target site of the patient.

[0010] This summary is intended to provide an overview of the subject matter described in this disclosure. It is not intended to provide an exclusive or exhaustive explanation of the apparatus and methods described in detail within the accompanying drawings and description below. The details of one or more aspects of the disclosure are set forth in the accompanying drawings and the description below.

BRIEF DESCRIPTION OF DRAWINGS

[0011] FIG. **1**A is a conceptual diagram illustrating an example therapy system comprising a leadless implantable medical device (IMD) that may be used to monitor one or more physiological parameters of a patient and/or provide therapy to the heart of a patient.

[0012] FIG. **1**B is a conceptual diagram illustrating another example therapy system comprising an IMD coupled to a plurality of leads that may be used to monitor one or more physiological parameters of a patient and/or provide therapy to the heart of a patient.

[0013] FIG. **2**A is a conceptual diagram illustrating an example delivery device that includes an elongated member, a deployment bay that is housing an example IMD, two electrodes, and circuitry that is configured to use impedance of an electrical signal between the two electrodes to determine if one of the deployment bay or IMD are defining a fixation configuration.

[0014] FIG. **2**B is a conceptual diagram illustrating a cross-sectional view through the elongated member of the delivery device of FIG. **2**A.

[0015] FIG. **2**C is a conceptual diagram illustrating an example first and second electrode on the deployment bay of FIG. **2**A for verifying if the deployment bay is defining a first fixation configuration as well as an example first and second electrode on the IMD of FIG. **2**A for verifying if the IMD is defining a second fixation configuration.

[0016] FIG. **2**D is a conceptual diagram illustrating an example first electrode on the deployment bay of FIG. **2**A for verifying if the deployment bay is defining a first fixation configuration as well as an example first electrode on the IMD of FIG. **2**A for verifying if the IMD is defining a second fixation configuration, wherein both first electrodes are configured to be used with a common second electrode on the deployment bay.

[0017] FIG. **2**E is a conceptual diagram illustrating an example first and second electrode that are both secured to the IMD of FIG. **2**A such that both are used to verifying if the deployment bay is defining the first fixation configuration and the IMD is defining a second fixation configuration as a result of a first set of holes through the wall of the deployment bay.

[0018] FIG. **2**F is a conceptual diagram illustrating an example first and second electrode that are both secured to the IMD of FIG. **2**A such that both are used to verifying if the deployment bay is defining the first fixation configuration and the IMD is defining a second fixation configuration as a result of a second set of holes through the wall of the deployment bay and one or ribs of deployment bay.

[0019] FIG. **2**G is a conceptual diagram illustrating a cross-sectional view of the deployment bay, second electrode and ribs of FIG. **2**F.

[0020] FIG. **2**H is a conceptual diagram illustrating an example first electrode in the deployment bay and a second electrode on the distal tip of the deployment bay of FIG. **2**A for verifying if the deployment bay is defining a first fixation configuration.

[0021] FIG. **2**I is a conceptual diagram illustrating an example first electrode comprised of the metal can of an IMD and a second electrode on the elongated member of the delivery device of FIG. **2**A for verifying if the deployment bay is defining a first fixation configuration.

[0022] FIG. **3** is a conceptual block diagram illustrating example configuration of circuitry of a system including a delivery device, the circuitry configured to verify when a delivery device and/or IMD define one or more fixation configurations.

[0023] FIG. **4**A is a conceptual diagram illustrating a side view of the delivery device of FIG. **2**A defining a first non-fixation configuration relative to a target site.

[0024] FIG. **4**B is a conceptual diagram illustration a side view of the delivery device of FIG. **2**A defining a first fixation configuration relative to a target site.

[0025] FIGS. **5**A and **5**B are conceptual diagrams illustrating views of the delivery device and IMD of FIG. **2**A approaching a target site and defining a second non-fixation configuration relative to the target site, respectively.

[0026] FIGS. **5**C and **5**D are conceptual diagrams illustrating views of the delivery device and IMD of FIG. **2**A approaching a target site and defining a second fixation configuration relative to the target site, respectively.

[0027] FIG. **6** is a chart of example impedance data that indicates a first fixation configuration.

[0028] FIG. **7** is a chart of example phase data that indicates a first fixation configuration.

[0029] FIG. **8**A is a chart of example impedance data that indicates a second non-fixation configuration.

[0030] FIG. **8**B is a chart of example impedance data that indicates a second fixation configuration.

[0031] FIG. **9**A is a chart of example phase data that indicates a second non-fixation configuration.

[0032] FIG. **9**B is a chart of example phase data that indicates a second fixation configuration.

[0033] FIG. **10**A is a chart of example FFT data that indicates a second non-fixation configuration.

[0034] FIG. **10**B is a chart of example FFT data that indicates a second fixation configuration.

[0035] FIG. **11** depicts a flowchart of an example method of processing circuitry verifying that electrical signals indicate that a delivery device and IMD are defining one or more fixation configurations relative to a target site.

[0036] FIG. **12** depicts a flowchart of an example method of a clinician deploying an IMD to a target site while verifying that a delivery device and IMD are defining one or more fixation configurations relative to the target site.

DETAILED DESCRIPTION

[0037] Aspects of this disclosure relate to methods and systems for delivering an implantable medical device (IMD) to a target site in a patient and therein verifying efficacious fixation configuration of the delivery device and IMD relative to the target site. The IMD may be secured to the target site once navigated to the target site with fixation elements on or near a distal end of the IMD. The delivery device may include a navigable elongated member (e.g., a catheter), a deployment bay at a distal end of the elongated member, and a verification system that is configured to verify when the delivery device and/or IMD define one or more fixation configurations relative to the target site. For example, aspects of the methods and systems disclosed herein relate to providing an electrical signal to fluid and/or tissue of the patient between electrodes of the system, and therein analyzing an impedance of the delivered electrical signal to verify when the delivery device and/or IMD define fixation configurations relative to the target site.

[0038] The delivery device and/or IMD may include a first electrode that is contained within a deployment bay of the delivery device during intravascular navigation and at least a second electrode. Further, the delivery device and/or IMD may include circuitry that is configured to deliver (and then analyze) an electrical signal to fluid and/or tissue between two electrodes. For example, a first electrode may be secured to an inner surface (e.g., a surface that faces the IMD) of the deployment bay and a second electrode may be secured to an outer surface (a surface that faces the vasculature) of the deployment bay, and circuitry may be configured to provide an electrical signal to fluid and tissue between the two electrodes. The circuitry may therein be configured to monitor an impedance of the electrical signal as provided across the electrodes, and identify when the signal rises above a threshold magnitude. Where the IMD includes distal-extending fixation elements of the IMB, deploying the IMB from the deployment bay at an angle that is substantially square to the surface of the tissue site may improve an ability of the fixation elements to secure the IMD to the tissue. As such, configuring the circuitry to detect when an impedance of an electrical signal provided across the distal port of the deployment bay may functionally provide an indication as to when the delivery device defines an efficacious deployment arrangement. The circuitry may be configured to provide an indication to a clinician as to when the delivery device defines such a fixation configuration (e.g., using a user interface of the system).

[0039] Similarly, the IMD may include a first electrode that is secured to a distal tip of the IMD and a second electrode that is proximal to the distal tip. In some examples, the first electrode of the delivery device may be the first electrode of the IMD. In such examples, the second electrode of the delivery device may be a second electrode of the IMD that is secured to the IMD at a location proximal to the distal tip of the IMD, or the second electrode may be secured to the deployment receptacle at a location proximal to the distal tip of the IMD. In other examples, the delivery device may include two discrete electrodes and the IMD may include two discrete electrodes, such that the full system includes two sets of electrodes that each verify one of the fixation configurations. Circuitry of the IMD may be configured to provide an electrical signal to fluid and tissue between the first electrode on the distal tip and the second electrode proximal to the first electrode. The circuitry may therein be configured to monitor an impedance of the electrical signal as provided across the electrodes, and identify if the signal incorporates any harmonics over time and during a stress test. Where the IMD includes a therapeutic element on its distal tip (e.g., such as an electrode configured to provide therapy or sensing to a patient), the IMD may have an improved ability to provide therapy using

this therapeutic element when the IMD is squarely and securely pressing the therapeutic element into tissue of the patient. As such, configuring the circuitry to detect when an impedance of an electrical signal provided through an electrode on the distal tip includes harmonics may functionally provide an indication as to when the IMD has not been deployed such that a therapeutic element on its distal tip is squarely and securely pressing into tissue at the target site. The circuitry may be configured to provide an indication to a clinician as to when the IMD is not identifying an impedance with such harmonics and is therein defining an efficacious fixation configuration.

[0040] FIG. **1**A is a conceptual diagram illustrating an example therapy system **10**A that may be used to monitor one or more physiological parameters of heart **12** of patient **14** and/or to provide therapy to heart **12** of patient **14** using one or more medical devices delivered using the delivery device of this disclosure. Patient **14** is ordinarily, but not necessarily, a human patient. Therapy system **10**A includes implantable medical device (IMD) **16**A, which is communicatively coupled, e.g., wirelessly, to external device **18**. IMD **16**A may be an implantable leadless pacemaker that provides electrical signals to heart **12** via one or more electrodes (not shown in FIG. **1**) on its outer housing. Additionally, or alternatively, IMD **16**A may sense electrical signals attendant to the depolarization and repolarization of heart **12** via electrodes on its outer housing. In some examples, IMD **16**A provides pacing pulses to heart **12** based on the electrical signals sensed within heart **12**. For example, IMD **16**A may be a Micra™ device of the Transcatheter Pacing System (TPS), which is commercial available from Medtronic Public Limited Company, of Dublin, Ireland.

[0041] IMD **16**A may include circuitry within a hermetically sealed housing of IMD **16**A. IMD **16**A may also include a power source and/or memory for circuitry **28**. Circuitry **28** may be configured to provide the functionality attributed to IMD **16**A as described herein. For example, as described in greater detail below, circuitry **28** of IMD **16**A may include circuitry configured to provide electrical signals across electrodes to verify that a delivery device and/or IMD **16**A is defining efficacious fixation configurations during a deployment procedure. These electrical signals may include sinusoidal waveforms and/or pulses. Circuitry **28** may include one or more microprocessors, digital signal processors (DSPs), application specific integrated circuits (ASICs), field programmable gate arrays (FPGAs), or any other equivalent integrated or discrete logic circuitry, as well as any combinations of such components.

[0042] For example, circuitry **28** may include processing circuitry, stimulation circuitry, telemetry circuitry, sensing circuitry, or the like. Stimulation circuitry may generate and deliver electrical stimulation under the control of processing circuitry. For example, in operation, processing circuitry may access a memory to load therapy programs to stimulation circuitry, where stimulation parameters of therapy programs may include a voltage amplitude, a current amplitude, a pulse rate, a pulse width, a duty cycle, or a combination of electrodes (e.g., where electrodes are secured to IMD **16**A). Further, stimulation circuitry may have some overlap with signal generation circuitry as described below (e.g., signal generation circuitry **124** of FIG. **3**).

[0043] Telemetry circuitry may be configured for wireless communication using radio frequency protocols or inductive communication protocols. Telemetry circuitry may include one or more antennas configured to communicate with external device **18**, for example. Processing circuitry may transmit operational information such as sensing information and receive therapy programs or therapy parameter adjustments via telemetry circuit. Also, in some examples, IMD **16**A may communicate with other implanted devices, such as stimulators, control devices, or sensors, via telemetry circuit. Sensing circuitry may be configured to sense one or more parameters of patient **14**. For example, sensing circuitry may sense parameters of heart **12** using electrodes of IMD **16**A. Based on sensed values of sensing circuitry, processing circuitry may use telemetry circuitry to provide information or use stimulation circuitry to provide therapy related to sensed values. Further, as described herein, processing circuitry may use telemetry circuitry to send indications of fixation or indications of non-fixation to various user interfaces for a clinician.

[0044] IMD **16**A may include fixation elements such as a set of fixation tines to secure IMD **16**A to patient tissue. The fixation elements of IMD **16**A may be located near a distal end of IMD **16**A, such that the fixation elements are configured to extend out the distal opening of the deployment bay of the delivery device prior to and/or concurrently with IMD **16**A being deployed using the delivery device. In the example of FIG. **1**A, IMD **16**A is positioned wholly within heart **12** proximate to an inner wall of right atrium **20** to provide right atrium **20** pacing. In other examples, IMD **16**A may be positioned at any other location outside of or within heart **12**. For example, IMD **16**A may be positioned outside or within right ventricle **22**, left atrium **24**, and/or left ventricle **26** (e.g., to provide right ventricle, left atrial, and left ventricular pacing), respectively. Further, although a single IMD **16**A is shown in FIG. **1**A, system **10**A may include additional IMDs that are similar to or different from IMD **16**A.

[0045] Depending on the location of implant, IMD **16**A may include other stimulation functionalities. For example, IMD **16**A may provide atrioventricular nodal stimulation, fat pad stimulation, vagal stimulation, or other types of electrical stimulation. In other examples, IMD **16**A may be a monitor that senses one or more parameters of heart **12** (e.g., electrical activity mechanical activity, and/or blood pressure) and may not provide any stimulation functionality. In some examples, system **10**A may include a plurality of leadless IMDs **16**A to provide stimulation and/or sensing at a variety of locations.

[0046] As mentioned above, IMD **16**A may be delivered and deployed to its target site using the delivery device described herein. IMD **16**A may be contained substantially entirely within a deployment bay of the delivery device such that fixation elements of IMD **16**A are adjacent a distal opening of the deployment bay. Upon securing attachment of IMD **16**A to the target site (e.g., through fixation tines as depicted in FIG. **1**A), delivery device may be retracted from patient **14** (e.g., including retracting the delivery device over a proximal end of IMD **16**A, depending upon whether IMD **16**A may be secured before full deployment).

[0047] In many cases, an efficacy of IMD **16**A may be impacted by a quality of fixation of IMD **16**A. For example, IMD **16**A may include a plurality of fixation tines that are configured to press a distal electrode of IMD **16**A up against tissue of target site of patient **14**. If fixation tines have a disadvantageous fixation to the tissue, it may be difficult or

impossible for IMD **16**A to provide the functionality described herein using such a distal electrode. For example, if only one of a plurality of fixation tines is affixed to the tissue, or if fixation tines are affixing IMD **16**A at an angle relative to the tissue, a distal electrode may have relatively poor contact with the target site (e.g., poor contact with right atrium **20**). As a result of such poor contact (which is itself a result of disadvantageous fixation), an efficacy of IMD **16**A may be reduced.

[0048] In some examples, a clinician may utilize a "tug test" to verify if fixation elements of IMD **16**A have properly engaged tissue of the target site. A tug test may include tugging on a proximal end of IMD **16**A with, e.g., a tether (such as tether **162** of FIGS. **5**B and **5**D). In some examples, as depicted in FIGS. **5**B and **5**D, the tug test may be conducted when IMD **16**A is substantially entirely deployed out of deployment bay **52** and therein substantially unconstrained by deployment bay **52**. A clinician may view IMD **16**A at the target site using fluoroscopy or the like to ensure that fixation elements appear to have properly engaged tissue of the target site. However, in some examples, a target site may a relatively thin wall of tissue such that it may be difficult for a clinician to adequately see such engagement. For example, walls of right atrium **20** and/or left atrium **24** may be relatively thin, such that it is difficult or impossible for a clinician to verify that IMD **16**A has been efficaciously attached to tissue of the target site using fixation elements.

[0049] Aspects of this disclosure relate to verifying that one or both of a delivery device and IMD **16**A are defining advantageous fixation configurations that are likely to result in good contact of a distal electrode or the like of IMD **16**A with tissue of a target site. For example, a delivery device may be configured to provide an electrical signal to fluid and/or tissue of patient **14** between a first electrode within a deployment bay of the delivery device and a second electrode outside of the deployment bay. When a distal opening of the delivery device is not aligned with a target site (e.g., such that a face that defines the distal opening is at an angle relative to the tissue of the target site), the path between the two electrodes (e.g., the path of least resistance that the electrical between the electrodes will take) may substantially include fluid of patient **14**. Conversely, when a distal opening of the delivery device is aligned and adequately pressed into tissue of a target site, the path between the two electrodes may include at least some tissue of patient **14** (e.g., the path for the electrical signal to exit the enclosure of the deployment bay, such as through the distal port). A path through tissue of patient **14** may have a higher impedance than a path that substantially or entirely includes fluid of patient **14**. Processing circuitry (such as processing circuitry of the delivery device or circuitry **28** of IMD **16**A) may detect this relatively higher impedance, e.g., an impedance that exceeds or otherwise satisfies a threshold, and may cause a user interface (e.g., a screen or a light or the like) to indicate to a clinician that the delivery device is oriented properly for the deployment of IMD **16**A.

[0050] Additionally, or alternatively, processing circuitry (of the delivery device or of IMD **16**A) may be configured to send an electrical signal between a distal electrode of IMD **16**A and a second electrode proximal to the distal electrode of IMD **16**A after IMD **16**A is deployed. In this example, processing circuitry may be configured to evaluate the impedance of signal provided between the first electrode and another electrode after IMD **16**A has been deployed and secured to tissue. If the fixation elements of IMD **16**A (e.g., such as the fixation tines as described above) have pressed the first electrode against tissue of the target site, impedance of the signal may include substantially stable impedance values. Conversely, if the fixation means of IMD **16**A did not engage tissue of the target site as expected, the processing circuitry of the delivery device may identify harmonics in the impedance values of the electrical signal across the electrodes, such as bimodal signatures or relatively "noisy" slopes. Processing circuitry of the delivery device may determine whether the signal is "stable" or includes harmonics, and may cause a user interface (e.g., a screen or a light or the like) to indicate to a clinician that fixation means of IMD **16**A are well engaged or poorly engaged, respectively, as a result of this determination.

[0051] As a result of processing circuitry (of the delivery device and/or of IMD **16**A) verifying whether the delivery device is properly oriented for deployment and/or verifying whether IMD **16**A has achieved proper fixation post-deployment, the processing circuitry may improve an ability of a clinician to arrange system **10**A such that each IMD **16**A (and therein a distal electrode of each IMD **16**A) has good contact with tissue of intended target sites. As a result of IMDs **16**A having good contact, system **10**A may have an approved ability to treat and/or monitor patients **14** as described herein.

[0052] FIG. **1**A further depicts external device **18** such as a (clinician or patient) programmer in wireless communication with IMD **16**A. In some examples, external device **18** comprises a handheld computing device, computer workstation, or networked computing device. External device **18** may include a user interface that presents information to and receives input from a user. It should be noted that the user may also interact with external device **18** remotely via a networked computing device.

[0053] A user, such as a physician, technician, surgeon, electrophysiologist, other clinician, or patient, interacts with external device **18** to communicate with IMD **16**A. For example, the user may interact with external device **18** to retrieve physiological or diagnostic information from IMD **16**A. For example, the user may use external device **18** to retrieve information from IMD **16**A regarding the rhythm of heart **12**, heart rhythm trends over time, or arrhythmic episodes. A user may also interact with external device **18** to program IMD **16**A.

[0054] In some examples, the user may use external device **18** to retrieve information from IMD **16**A regarding other sensed physiological parameters of patient **14** or identify information that is derived from sensed physiological parameters, such as intracardiac or intravascular pressure, activity, posture, tissue oxygen levels, blood oxygen levels, respiration, tissue perfusion, heart sounds, cardiac electrogram (EGM), intracardiac impedance, thoracic impedance, or the like. In some examples, the user may use external device **18** to retrieve information from IMD **16**A regarding the performance or integrity of IMD **16**A or the performance or integrity of respective components of system **10**A, such as a power source of IMD **16**A. As another example, the user may interact with external device **18** to select values of parameters of therapies provided by IMD **16**A, such as pacing and/or neurostimulation therapies.

[0055] Further, in some examples external device **18** may include a user interface as described herein that is used to indicate fixation and/or non-fixation configurations to clini-

cian. For example, circuitry that is configured to deliver an electrical signal to tissue and/or fluid between two electrodes and therein use an impedance of the signal to verify whether or not a delivery device and/or IMD **16**A defines fixation configurations may then provide this information (using telemetry techniques described herein) to external device **18**. Further, a clinician may provide inputs or commands to circuitry regarding verifying or testing fixation configurations using external device **18**. For example, a clinician may use an interface of external device **18** to have circuitry of IMD **16**A and/or a delivery device start verifying whether the delivery device defines a first fixation configuration, stop verifying whether the delivery device defines the first fixation configuration, start verifying whether IMD **16**A defines the second fixation configuration, stop verifying whether IMD **16**A defines the second fixation configuration, or the like.

[0056] IMD **16**A and external device **18** may communicate via wireless communication using any technique known in the art. Examples of communication techniques may include low frequency or radiofrequency (RF) telemetry. In some examples, external device **18** may include a programming head that may be placed proximate to the patient's body near the IMD **16**A implant site in order to improve the quality or security of communication between IMD **16**A and external device **18**.

[0057] FIG. **1**B is a conceptual diagram illustrating another example therapy system **10**B that may be used to monitor one or more physiological parameters of patient **14** and/or to provide therapy to heart **12** of patient **14** using leads **30**A, **30**B, **30**C (collectively "leads **30**") implanted in patient **14** using the delivery device and methods described herein. Therapy system **10**B includes IMD **16**B which is coupled to leads **30** and external device **18**. As referred to herein, all of IMD **16**B and leads **30** may be collectively referred to generally as an IMD. In one example, IMD **16**B may be an implantable pacemaker that provides electrical signals to heart **12** via electrodes coupled to one or more of leads **30**. IMD **16**B may include an electrical stimulation generator and may be attached to the proximal end of medical leads **30**. In other examples, in addition to or alternatively to pacing therapy, IMD **16**B may deliver neurostimulation signals. In some examples, IMD **16**B may also include cardioversion and/or defibrillation functionalities. In other examples, IMD **16**B may exclusively or predominantly provide monitoring functionalities.

[0058] Medical leads **30** extend into the heart **12** of patient **14** to sense electrical activity of heart **12** and/or deliver electrical stimulation to heart **12**. In some examples, each medical lead **30** of FIG. **1**B may be delivered to their respective target sites using the delivery device according to the delivery techniques described herein. In the example shown in FIG. **1**B, right ventricular (RV) lead **30**B extends through one or more veins (not shown), the superior vena cava (not shown), right atrium **20**, and into right ventricle **22**. RV lead **30**B may be used to deliver RV pacing to heart **12**. Left ventricular (LV) lead **30**A extends through one or more veins, the vena cava, right atrium **20**, and into the coronary sinus **32** to a region adjacent to the free wall of left ventricle **26** of heart **12**. Alternatively, LV lead **30**A may be implanted "directly" into the left ventricle **26**, such that LV lead **30**A, e.g., extends through a hole in the ventricular septum or atrial septum. LV lead **30**A may be used to deliver LV pacing to heart **12**. Right atrial (RA) lead **30**C extends through one or more veins and the vena cava, and into the right atrium **20** of heart **12**. RA lead **30**C may be used to deliver RA pacing to heart **12**.

[0059] In some examples, system **10**B may additionally or alternatively include one or more leads or lead segments (not shown in FIG. **1**B) that deploy one or more electrodes within the vena cava or other vein, or within or near the aorta. Furthermore, in another example, system **10**B may additionally or alternatively include one or more additional intravenous or extravascular leads or lead segments that deploy one or more electrodes epicardially, such as near an epicardial fat pad, or proximate to the vagus nerve. In other examples, system **10**B may not include one of ventricular leads **30**A and **30**B.

[0060] One or more of medical leads **30** may include one or more fixation elements such as a set of fixation tines to secure a distal end of the medical lead to patient tissue or at a fixed position relative to patient tissue (e.g., where a fixation element of one or more medical leads **30** expands against rather than penetrates patient tissue). The inclusion of fixation elements such as tines for each medical lead **30** is merely illustrated for purposes of clarity, as in some examples other fixation means (such as a distal helical coil or the like) may be utilized. As depicted, fixation elements may include distal tines that are configured to distally extend from leads **30** and are self-biasing upon deployment (e.g., deployed from a deployment bay of a delivery device as described herein to a biased configuration). In other examples, fixation elements may include other types of tines, such as tines that do not self-bias (but are caused to bias or deform or actuate by another component), tines of other shapes (e.g., helical tines), tines that are configured to be manually controlled to a clinician, or the like. Fixation elements such as tines may be constructed of substantially any bio-compatible material.

[0061] As mentioned above, one or more medical leads **30** may be delivered and deployed to respective target sites using the delivery device described herein. Medical leads **30** may be deployed to respective target sites within or near heart **12** in subsequent procedures using one or more the delivery devices herein. In such examples, the fixation elements of the respective medical leads **30** may be navigated to the target site within a deployment bay of the delivery device, such that other portions of respective medical leads **30** may be housed by a lumen of some of the deployment bay and/or elongated member of the delivery device. Upon deploying the distal end of medical leads **30** to secure respective medical leads **30** to the target site, the delivery device may be withdrawn over respective medical leads **30** to retract the delivery device from patient **14**. In this way, upon successfully deploying one of medical leads **30**, a clinician may retract the delivery device such that the delivery device moves proximally relative to the respective deployed medical lead **30** (e.g., such that respective deployed and distally secured medical lead **30** slides within the one or more lumens of the delivery device as defined by the deployment bay and/or elongated member of the delivery device as the delivery device is retracted).

[0062] IMD **16**B may sense electrical signals attendant to the depolarization and repolarization of heart **12** via electrodes coupled to at least one of the leads **30**. In some examples, IMD **16**B provides pacing pulses to heart **12** based on the electrical signals sensed within heart **12**. The

configurations of electrodes used by IMD **16**B for sensing and pacing may be unipolar or bipolar.

[0063] IMD **16**B may also provide neurostimulation therapy, defibrillation therapy and/or cardioversion therapy via electrodes located on at least one of the leads **30**. For example, IMD **16**B may deliver defibrillation therapy to heart **12** in the form of electrical pulses upon detecting ventricular fibrillation of ventricles **22** and **26**. In some examples, IMD **16**B may be programmed to deliver a progression of therapies, such as pulses with increasing energy levels, until a fibrillation of heart **12** is stopped. As another example, IMD **16**B may deliver cardioversion or anti-tachycardia pacing (ATP) in response to detecting ventricular tachycardia, such as tachycardia of ventricles **22** and **26**.

[0064] As described above with respect to IMD **16**A of FIG. **1**, external device **18** such as a clinician or patient programmer may be used to communicate with IMD **16**B. In addition to the functions described with respect to IMD **16**A of FIG. **1**, a user may use external device **18** to retrieve information from IMD **16**B regarding the performance or integrity of leads **30** and may interact with external device **18** to select parameters for any additional therapies provided by IMD **16**B, such as cardioversion and/or defibrillation.

[0065] Leads **30** may be electrically coupled to signal generation circuitry and sensing circuitry (not shown) of IMD **16**B via connector block **34**. In some examples, proximal ends of leads **30** may include electrical contacts that electrically couple to respective electrical contacts within connector block **34** of IMD **16**B. Although not shown in FIG. **1**B, IMD **16**B may include circuitry **28**, similar to IMD **16**A. Circuitry **28** may include the processing circuitry, signal generation circuitry, and sensing circuitry described above, along with any other circuitry, power source, antennas, or other hardware or software necessary or helpful to configure IMD **16**B to provide therapy and/or monitor a condition of patient **14**. In some examples, signal generation circuitry of IMD **16**A may be used to deliver the electrical signal between electrodes described herein to verify fixation configurations. In other examples, leads **30** may be coupled to another system to generate electrical signals and identify impedance of those signals to verify fixation configurations as described herein.

[0066] The configuration of system **10**B illustrated in FIG. **1**B is merely one example. In other examples, a system may include extravascular leads, subcutaneous lead, substernal leads, epicardial leads and/or patch electrodes instead of or in addition to the transvenous leads **30** illustrated in FIG. **1**B. Further, IMD **16**B need not be implanted within patient **14**. For each of these examples, any number of the medical leads may include a set of fixation tines on a distal end of the medical lead that were navigated to their respective target sites using delivery devices in accordance with the techniques described herein.

[0067] In addition, in other examples, a system may include any suitable number of leads coupled to IMD **16**B, and each of the leads may extend to any location within or proximate to heart **12**. For example, other examples of systems may include three transvenous leads located as illustrated in FIG. **1**B, and an additional lead located within or proximate to left atrium **24**. Other examples of systems may include a single lead that extends from IMD **16**B into right atrium **20** or right ventricle **22**, or two leads that extend into a respective one of the right ventricle **22** and right atrium **20**. In each of these examples, any number of the medical leads may include a fixation mechanism on a distal end of the medical lead and may be delivered with a medical delivery device in accordance with the techniques described herein.

[0068] FIG. **2**A depicts an example medical delivery device **50** for delivering implantable medical devices such as IMD **16**A. Though delivery device **50** is depicted and discussed herein as deploying and verifying fixation configurations of and/or for IMD **16**A, it is to be understood that delivery device **50** may be used to deploy and verify fixation configurations for other IMDs or other IMD components (e.g., leads **30** of IMD **16**B) in other examples. Delivery device **50** may include deployment bay **52** that is configured to house at least a portion of IMD **16**A and deploy IMD **16**A. In some examples, deployment bay **52** may be configured to house substantially all of IMD **16**A prior to deploying IMD **16**A. Deployment bay **52** may be connected to a distal portion of elongated member **54** of delivery device **50**. Deployment bay **52** and elongated member **54** may be configured to navigate an intravascular system of a patient. For example, a clinician may navigate deployment bay **52** and elongated member **54** through an intravascular system until deployment bay **52** is at a target site in a patient in order to deploy IMD **16**A from deployment bay **52**. A clinician may use hub **56** of delivery device **50** to handle delivery device **50** and/or navigate deployment bay **52** to a target site. Hub **56** of delivery device **50** may be at proximal portion **58** of delivery device **50**. In some examples, hub **56** may be configured to remain external to patient **14** as deployment bay **52** is navigated to the target site, enabling a clinician to navigate an intravenous system and deploy IMD **16**A using one or more mechanisms or ports (not depicted) of hub **56**. Deployment bay **52** may be located at or near a distal end of delivery device **50**, and hub **56** may be located at or near a proximal end of delivery device **50**, with elongated member **54** extending between hub **56** and deployment bay **52**.

[0069] Elongated member **54** may be a flexible elongated component that longitudinally extends along delivery device **50**. Elongated member **54** may extend between deployment bay **52** and hub **56** of delivery device **50** along longitudinal axis **60** of delivery device **50**. Elongated member **54** may be substantially cylindrical such that elongated member **54** defines a substantially circular cross-sectional shape. In other examples, elongated member **54** may define one or more other cross-section shapes, including defining a plurality of cross-sectional shapes along a longitudinal length of elongated member **54**.

[0070] Elongated member **54** may define a number of longitudinal lumens for a variety of purposes. For example, as depicted in conceptual cross-sectional view of FIG. **2**B as taken along cut-line **62**, elongated member **54** may define lumen **64** that occupies a majority of a cross-sectional width of elongated member **54**. Lumen **64** may be configured to house deployment mechanism **66** that can axially slide (e.g., slides along longitudinal axis **60** of delivery device **50**) within lumen **64** relative to delivery device **50**. In this way, a clinician may, e.g., deploy IMD **16**A from deployment bay **52** once the clinician navigates deployment bay **52** to a target site as a result of an action executed using deployment mechanism **66**. For example, turning back to FIG. **2**A, deployment mechanism **66** may include pushing element **68** at a distal end of deployment mechanism **66**. Pushing element **68** may be configured to contact and impart a distal

force on a proximal face of IMD **16**A in response to deployment mechanism **66** being slide distally within lumen **64**. Additionally, or alternatively, deployment mechanism **66** may include a tether or catch (e.g., similar to tether **162** of FIGS. **5**B and **5**D) that is used to hold, push, retract, or otherwise move IMD **16**A relative to deployment bay **52**.

[0071] Turning back to FIG. **2**B, lumen **64** may alternatively or additionally be configured to house a portion of an insertable or implantable medical device (e.g., where an implantable medical device includes one of leads **30** of FIG. **1**B) to be deployed by delivery device **50**. Elongated member **62** may further define guidewire lumen **70** that is configured to house a guidewire that can axially slide (e.g., move along longitudinal axis **60** of delivery device **50**) within guidewire lumen **70** relative to delivery device **50** (e.g., such that deployment bay **52** is navigated to the target site by sliding delivery device **50** along a guidewire that was previously navigated to the target site). Alternatively, or additionally, one or more deflection members **72** may be embedded within elongated member **54**. Deflection members **72** may be configured to deflect elongated member **54** in one or more directions. For example, deflection members **72** may include wires that are pulled or pushed using a port or control member on hub **56** to deflect elongated member **54**. Deflection members **72** may be configured to deflect elongated member **54** in a predetermined manner that is configured to navigate delivery device **50** to the target site. Put differently, deflection members **72** as longitudinally embedded within elongated member **54** may be configured to deflect elongated member **54** in a predetermined manner when delivery device **50** is inserted in patient **14** (e.g., to navigate through a particularly tortuous and predetermined length of intravenous system).

[0072] Turning back to FIG. **2**A, as discussed above, delivery device **50** may be configured to be inserted into patient **14** to deliver IMD **16**A. In some examples, delivery device **50** may be configured to be inserted into patient **14** using an introducer sheath (not depicted). Delivery device **50** may be made of one or more biocompatible materials. For example, delivery device **50** may include polymeric materials such as polyether block amide (PEBA), low density polyethylene (LDPE), high density polyethylene (HDPE), polytetrafluoroethylene (PTFE), polybutylene terephthalate (PBT), polyethylene terephthalate (PET), nylons, or the like, and/or delivery device **50** may be made out of metallic materials such as titanium, nitinol, stainless steel, or the like.

[0073] In some examples, as depicted in FIG. **2**A, deployment bay **52** may house IMD **16**A within recess **74** as defined by outer wall **76** of deployment bay **52**. Deployment bay **52** may define recess **74** as a physical space that is sized to partially or entirely contain IMD **16**A as delivery device **50**. Outer wall **76** may enclose an axial length of IMD **16**A. In some examples, as depicted, outer wall **76** may extend radially in at a proximal end of deployment bay **52** to block proximal movement of IMD **16**A relative to deployment bay **52**. Though deployment bay **52** is depicted as transparent in FIG. **2**A for purposes of illustration (to depict IMD **16**A), it is to be understood that deployment bay **52** may define a substantially continuous enclosure that may or may not be transparent and mostly or fully radially encloses IMD **16**A along a length of IMD **16**A.

[0074] Deployment bay **52** may define distal opening **78** to recess **74** through which IMD **16**A. Delivery device **50** may be configured to deploy IMD **16**A from recess **74** through distal opening **78**. In some examples, distal surface **80** of deployment bay **52** may define distal opening **78**. Deployment bay **52** may define recess **74** such that, when IMD **16**A is received within recess **74**, one or more fixation elements **82** are proximal to distal opening **78**. In some examples, one or more fixation elements **82** may interface with an inner surface of outer wall **76** of deployment bay **52** prior to and during the navigation of IMD **16**A to a target site. Put differently, a distal end of fixation elements **82** may contact an inner surface of outer wall **76** when IMD **16**A is within deployment bay **52**, and further, fixation elements **82** may press against the inner surface and/or distal surface **80** to deploy IMD **16**A at the target site.

[0075] Delivery device **50** may include a plurality of electrodes and a set of circuitry that is configured to verify when deployment bay **52** and/or IMD **16**A defines one or more fixation configurations relative to tissue of a target site within patient **14**. For example, delivery device **50** may include first electrode **90**, second electrode **92**, and circuitry **94** for verifying if deployment bay **52** and/or IMD **16**A defines a fixation configuration. Circuitry **94** may be configured to cause first electrode **90** and second electrode **92** to deliver an electrical signal to fluid and/or tissue along a path between first electrode **90** and second electrode **92**. Circuitry **94** may then use a determined impedance of the electrical signal across this path to verify whether the deployment bay **52** and/or IMD **16**A are defining a fixation configuration relative to target site tissue. The depicted location and size of each of first electrode **90**, second electrode **92**, and circuitry **94** is for purposes of illustration only, as each of these components may be at many locations and may be sized and shaped differently as described herein (e.g., as depicted in FIGS. **2**C and **2**D).

[0076] First electrode **90** may be located within recess **74** of deployment bay **52**. For example, first electrode **90** may be secured to an inner surface of outer wall **76** of deployment bay **52**. Alternatively, first electrode **90** may be secured to distal tip **96** of housing **98** of IMD **16**A. In such examples, first electrode **90** may be the primary sensing/pacing/defibrillation electrode of IMD **16**A. Regardless of location, first electrode **90** may be configured to be exposed to fluid of a patient when deployment bay **52** is navigated to a target site. Put differently, a conductive surface of first electrode **90** may be configured to directly electrically couple with a fluid (e.g., such as blood) of a patient when deployment bay **52** is navigated to a target site in a patient.

[0077] In some examples, second electrode **92** may be located outside of recess **74** of deployment bay **52**. For example, second electrode **92** may be secured to an outer surface of outer wall **76** of deployment bay **52**. In other examples, second electrode **92** may be secured to an outer surface of a distal portion of elongated member **54**, or second electrode **92** may be secured to a transition between elongated member **54** and deployment bay **52**. Alternatively (or additionally as described below), second electrode **92** may be located within recess **74** of deployment bay **52**. For example, second electrode **92** may be secured to proximal portion **100** of IMD **16**A. Similar to first electrode **90**, second electrode **92** may be configured to be exposed to a fluid of patient **14** when deployment bay **52** is navigated to a target site in patient **14**.

[0078] Both first electrode **90** and second electrode **92** may be electrically coupled to circuitry **94**. Delivery device

50 may include one or more conductors configured to electrically couple first electrode 90 and second electrode 92 to circuitry 94. For example, turning back to FIG. 2B, first conductor 102A and second conductor 102B (collectively, "conductors 102") may extend longitudinally throughout delivery device 50 embedded in wall of elongated member 54. First conductor 102A may be coupled to first electrode 90 and second conductor 102B may be coupled to second electrode 92. In other examples (not depicted), one or both of conductors 102 may be embedded within deployment mechanism 66 or may be configured to extend within a lumen of (rather than be embedded within) elongated member 54. For example, one or both of conductors 102 may extend longitudinally within lumen 64 of elongated member 54.

[0079] Conductors 102 may be electrically insulated from each other as they extend longitudinally through delivery device 50. In other examples (e.g., where circuitry 28 of IMD 16A comprises some or all of circuitry 94 as described herein), conductors 102 may extend entirely or partially within IMD 16A to coupled circuitry 94 to first electrode 90 and second electrode 92.

[0080] Turning back to FIG. 2A, as depicted circuitry 94 may be located within delivery device 50. For example, circuitry 94 may be located within hub 56 of delivery device 50. In other examples, circuitry 94 may be within a separate housing that may be coupled to delivery device 50. For example, circuitry 94 may be contained within an enclosure that may be coupled to delivery device 50 (e.g., coupled to ports of hub 56 in such a way that circuitry 94 of the enclose is electrically coupled to conductors 102 and therein first electrode 90 and second electrode 92 of delivery device 50). Alternatively, some of all of circuitry 94 may be included in circuitry 28 of IMD 16A as depicted in FIG. 1A. For example, first electrode 90 may be on distal tip 96 of IMD 16A, second electrode 92 may be secured to proximal portion 92 of IMD 16A, and circuitry 94 may be within a hermetically sealed housing of IMD 16A, such that techniques for verifying a fixation of IMD 16A to the target site are executed by components solely of IMD 16A.

[0081] Circuitry 94 may include circuitry configured to deliver an electrical signal to fluid and/or tissue along a path between first electrode 90 and second electrode 92. For example, circuitry 94 may be configured to couple first electrode 90 to a positive or supply terminal of an energy supply and couple second electrode 92 to a negative or return terminal of an energy supply. In this way, circuitry 92 may create an electrical circuit when a conductive medium such as tissue or fluid is provided on the path between first and second electrodes 90, 92. The path may include fluid and/or tissue at the target site of patient 14. In some examples (e.g., where circuitry 94 uses a power source such as a battery to generate the electrical signal), circuitry 94 may be configured to maintain a substantially static voltage potential or a substantially static current across first electrode 90 and second electrode 92 (through substantially static voltage potentials are predominantly discussed herein for purposes of clarity). This static voltage or current may be provided in a sinusoidal or pulse format. As a result of first electrode 90 and second electrode 92 delivering an electrical signal with a substantially static voltage potential or current, a value of the impedance of the signal may be reliably correlated to changes in the materials of the path. Put differently, as a result of providing a known and/or constant voltage, a resistance of the path traveled by the signal may be calculated by measuring the current, and alternatively as a result of providing a known and/or constant current, a resistance of the path may be calculated by measuring the voltage. For example, tissue of patient 14 may have relatively higher electrical resistance than fluid of patient 14, such that an impedance of the signal may increase when the electrical signal passes through tissue rather than just fluid of patient 14.

[0082] Circuitry 94 may identify an impedance of the electrical signal. Internal signal 94 may determine when the impedance indicates that the deployment bay 52 and/or IMD 16A define one or more fixation configurations. For example, circuitry 94 may cause first electrode 90 within deployment bay 52 and second electrode 92 secured to outer surface of deployment bay 52 to delivery electrical signal to fluid of patient 14 that is between first and second electrodes 90, 92. When distal surface 80 of deployment bay 52 that defines distal opening 78 is not flush against tissue of patient 14 (e.g., such that fluid of the patient 14 can flow into and out of recess 74 through distal opening 78), the electrical signal may follow a path that does not pass through any tissue of patient 14. Circuitry 94 may be configured to identify that the impedance of the electrical signal is lower than a predetermined threshold value (e.g., a level that indicates that the electrical signal has passed through tissue). Similarly, when distal surface 80 of deployment bay 52 is flush against tissue of patient 14, the path of the electrical signal may go through at least some tissue (e.g., as a result of fluid of the patient 14 being trapped in deployment bay 52). As a result of the path including at least some tissue, an impedance of the electrical signal between first electrode 90 inside recess 74 and second electrode 92 outside of recess 74 may increase. Circuitry 94 may identify that the impedance of the electrical signal has raised above the impedance threshold, indicating that the distal surface 80 of the deployment bay 52 is flush (substantially or adequately) against the target site, and therein deployment bay 52 is defining a first fixation configuration.

[0083] As a result of deployment bay 52 defining a first fixation configuration, circuitry 94 may cause user interface 104 to indicate the realization of the first fixation configuration (e.g., first fixation configuration 152A as depicted in FIG. 4B). User interface 104 may include an interface that is configured to present information or data or feedback to a user such as a clinician. For example, user interface 104 may include a display screen, a speaker or other device capable of provide audible feedback, or a haptic device. Where user interface 104 is a display screen, circuitry 94 may be configured to cause user interface 104 to present current impedance values to a clinician (e.g., by displaying text or imagery that indicates a successful first fixation configuration and/or a non-successful first fixation configuration, and/or one or more transformations between the two). In some examples, user interface 104 may be located on programmer 18 of FIGS. 1A and 1B, such as where user interface 104 is a display of programmer 18 and circuitry 94 communicates with user interface 104 using telemetry techniques as described herein.

[0084] Alternatively, or additionally, user interface 104 may be located on a proximal portion of delivery device 50. For example, user interface 104 may be located on hub 56 of delivery device 50. Where circuitry 94 is located on a separate device as described herein, user interface 104 may

be located on the same device. In some examples, user interface **104** may include a light such as a light-emitting diode (LED) or the like. For example, where user interface **104** includes an LED, circuitry **94** may be configured to cause LED to display a first predetermined color (e.g., red) in response to identifying that the impedance of the electrical signal is below the threshold level (e.g., such that deployment bay **52** does not define the first fixation configuration) and subsequently display a second predetermined color (e.g., green) in response to identifying that the impedance of the electrical signal rises above the threshold level (e.g., as a result of deployment bay **52** defining the first fixation configuration relative to the target site), flipping back and forth between the two in response to changing impedance levels.

[0085] Alternatively, or additionally, circuitry **94** may be configured to verify when an electrical signal between first electrode **90** and second electrode **92** indicates that IMD **16**A defines a second fixation configuration with tissue of a target site of patient **14**. For example, first electrode **90** may be secured to distal tip **96** of IMD **16**A, and second electrode **92** may be secured to an outer surface of outer wall **76** of deployment bay **52**. As discussed herein, first electrode **90** may be configured to press into tissue at the target site of patient **14** upon deployment from deployment bay **52**. In some examples, the target site may be a target site at or within heart **12** of patient **14**.

[0086] In some examples where the target site is at or within heart **12** of patient **14**, a manner in which IMD **16**A presses into heart **12** may impact an efficacy of treatment and/or monitoring provided by IMD **16**A. For example, where IMD **16**A is deployed from deployment bay **52** such that only one of fixation elements **82** becomes secured to target site, first electrode **90** may not press into tissue "square" such that one side of first electrode **90** is not contacting the tissue, or first electrode **90** may be pressed into the tissue with less than a threshold force such that signals between tissue and first electrode **90** are not passed efficaciously. When IMD **16**A is deployed such that first electrode **90** on distal tip **90** of IMD **16**A does not press into tissue as desired, it may be difficult or impossible for IMD **16**A to provide monitoring, pacing, or defibrillation techniques as desired. Circuitry **94** may be configured to verify when fixation elements **82** cause first electrode **90** to press into tissue of the target site squarely (e.g., straight-on such that a longitudinal axis of IMD **16**A is at a right angle with a surface of the target site) with at least a threshold force.

[0087] For example, circuitry **94** may analyze a "stability" or a "clarity" of an impedance of the electrical signal passed between first electrode **90** and second electrode **92**, where stability or clarity indicate a smooth and nonvolatile set of slopes of the impedance waveform as discussed herein. Put differently, as a result of IMD **16**A being deployed near or within heart **12**, an impedance of the electrical signal as sent between a path of tissue and fluid between first and second electrodes **90**, **92** may reflect and/or incorporate intrinsic waveforms of heart **12** (e.g., electrocardiography waveforms, phase waveforms, pressure waveforms). The impedance of the electrical signal as detected by circuitry **94** may reflect these intrinsic waveforms with more "clarity" or with "noise" (e.g., noise being series of relatively non-smooth slopes between repeated peaks and valleys of a waveform, and/or a bimodal signature within the waveform) depending upon the quality of the deployment of IMD **16**A from deployment bay **52**. Further, circuitry **94** may be configured to isolate or highlight this noise or clarity. For example, circuitry **94** may be configured to determine a first derivative of the impedance values, such that any noise may be magnified and therein be easier to identify. Additionally, or alternatively, circuitry **94** may be configured to execute fast Fourier transform (FFT) algorithms over the impedance values to isolate specific frequency components of the signal, therein analyzing these frequency components for noise or clarity. Further, circuitry **94** may be configured to identify an amount of lag between the current and the voltage across the electrodes **90**, **92** to identify a phase of the impedance of the electrical signal, and therein identify if the phase waveform satisfies various noise thresholds as described herein.

[0088] When IMD **16**A is deployed in such a manner that first electrode **90** on distal tip **96** of IMB **16**A presses loosely or at an angle into tissue of the target site, the impedance of the electrical signal as identified by circuitry **94** may be relatively noisy. Conversely, where IMB **16**A is deployed such that first electrode **90** on distal tip **96** presses squarely with at least a threshold force into tissue of the target site, the impedance waveform as identified by circuitry **94** repeatable, predictable, and may be maintain a magnitude. In some examples, a clinician may determine that IMD **16**A defines a second fixation configuration when circuitry **94** indicates that an impedance waveform maintains a relatively static and stable waveform upon (such that the impedance waveform does not acquire a bimodal signature or define slopes that are too noisy to be within a predetermined slope threshold) even when the IMD **16**A is tugged upon deployment.

[0089] As a result of circuitry **94** determining that an impedance indicates that IMD **16**A defines the second fixation configuration, circuitry **94** may cause user interface **104** to indicate the realization of the second fixation configuration. For example, where user interface **104** is an LED, circuitry **94** may be configured to cause LED to display a predetermined color (e.g., blue) in response to identifying that the impedance waveform is stable and relatively static (e.g., as a result of IMD **16**A defining the second fixation configuration relative to the target site). Alternatively, where user interface **104** is a display screen (e.g., where external device **18** comprises user interface **104**), circuitry **94** may be configured to cause user interface **104** to present impedance waveforms and/or noise levels to a clinician, along with a "pass" or "fail" message.

[0090] In some examples, delivery device **50** may include one or more radiopaque elements that may indicate a location of deployment bay **52** within patient. For example, deployment bay **52** may include radiopaque elements that enable a clinician monitoring an intravenous navigation of delivery device **50** to determine when deployment bay **52** has arrived at a target site. A clinician may track a location of deployment bay **52** using various fluoroscopy techniques. Radiopaque element may be secured to elongated member **54** at a location immediately proximal to deployment bay **52**, and/or radiopaque elements may be secured to deployment bay **52**. Radiopaque elements include a band of radiopaque materials that is embedded within delivery device **50**, a band that runs along an outer circumference of a portion of delivery device **50**, a doped portion of delivery device **50** (e.g., relative to adjacent portions), or the like. In other examples, a clinician may track a location of deployment

bay **52** using materials of IMB **16**A. For example, a clinician may track a progress of an electrode on distal tip **96** of IMB **16**A to track a location of deployment bay **52**.

[0091] As discussed above, delivery device **50** may include two or more electrodes. For example, as depicted in the conceptual diagram of FIG. **2**C illustrating a side view of delivery device **50** with IMD **16**A out of deployment bay **52**, deployment bay **52** may include one pair of first electrode **90**A and second electrode **92**A while IMD **16**A includes a second pair of first electrode **90**B and second electrode **92**B. First electrode **90**A may include a conductive material that is secured to an inner surface of outer wall **76** of deployment bay, and second electrode **92**A may include a conductive material that is secured to an outer surface of outer wall **76** of deployment bay **52**. First electrode **90**A may only expose a conductive material to the inner surface of deployment bay **52**, while second electrode **92**A only exposes a conductive material to the outer surface of deployment bay **52**. Additionally, first electrode **90**B may be secured to distal tip **96** of housing of IMD **16**A, while second electrode **92**B is secured to proximal portion **100** of IMD **16**A. Both first electrodes **90**A, **90**B may be substantially similar to first electrode **90** with the exception of any differences described herein. Similarly, both second electrodes **92**A, **92**B may be substantially similar to second electrode **92** as described herein with the exception of any differences described herein.

[0092] Circuitry **94** may be configured to provide a first electrical signal between first electrode **90**A and second electrode **92**A of deployment bay to determine if deployment bay **52** defines a first fixation configuration. Additionally, circuitry **94** may be configured to provide a second electrical signal between first electrode **90**B and second electrode **92**B of IMD **16**A to determine if IMD **16**A defines second fixation configuration. In some examples, a different set of circuitry **94** may provide and analyze first electrical signal as provides and analyzes second electrical signal. For example, first set of circuitry **94** may reside in hub **56** of delivery device **50**, while circuitry **28** of IMD **16**A may comprise second set of circuitry **94**. Alternatively, in some examples a single set of circuitry **94** may provide and analyze both first electrical signal between first and second electrodes **90**A, **92**A of deployment bay **52** as well as second electrical signal between first and second electrodes **90**B, **92**B of IMD **16**A.

[0093] Alternatively, in some examples, delivery device **50** may include one common electrode that sends a signal to two (or more) other electrodes to verify fixation configurations. For example, as depicted in the conceptual diagram of FIG. **2**D illustrating a side view of delivery device **50** with IMD **16**A out of deployment bay **52**, deployment bay **52** may include one pair of first electrode **90**A and second electrode **92**A while IMD **16**A includes a second version of first electrode **92**A. Circuitry **94** of delivery device **50** may be configured to provide a first electrical signal between first electrode **90**A of deployment bay and second electrode **92**A to determine if deployment bay **52** defines a first fixation configuration, as well as being configured to provide a second electrical signal between first electrode **90**B of IMD **16**A and second electrode **92**A to determine if IMD **16**A defines second fixation configuration. Put differently, in some examples a common electrode (here, second electrode **92**) may be configured to provide an electrical signal to two different paths between two different electrodes (here, first electrode **90**A and first electrode **90**B).

[0094] In some examples, delivery device **50** may be configured to use first electrode **90**B and second electrode **92**B of IMD **16**A to both verify a first and a second fixation configuration. For example, as depicted in the conceptual diagram of FIG. **2**E illustrating a side view of delivery device **50** with IMD **16**A housed within deployment bay **52**, deployment bay **52** may include define one or more holes **86**A through outer wall **76** of deployment bay **52** while IMD **16**A includes first electrode **90**B and second electrode **92**B. One or more holes **86**A of deployment bay **52** may extend radially through outer wall **76**. One or more holes **86**A may be configured to enable blood to flow through holes **86**A to access second electrode **92**B. In some examples, one or more holes **86**A may be located along deployment bay **52** at a location that is adjacent where second electrode **92**B may be located when IMD **16**A is housed within deployment bay **52**. As depicted, deployment bay **52** may define a plurality of holes **86**A at a plurality of radial and longitudinal locations. Further, in some examples IMD **16**A may be configured to generally engage an inner surface of outer wall **76** of deployment bay (e.g., such that an outer diameter of IMD **16**A is only nominally smaller than an inner diameter of deployment bay **52**), such that it is difficult for fluid to flow within deployment bay **52** between first electrode **90**B and second electrode **92**B. Rather, for fluid to flow between first electrode **90**B and second electrode **92**B, such fluid may flow out of distal opening **74** and then through one of one or more holes **86**A to define such a path. Circuitry **94** of delivery device **50** (e.g., which may be included within circuitry **28** of IMD **16**A) may be configured to provide a first electrical signal between first electrode **90**B and second electrode **92**B to determine if deployment bay **52** defines a first fixation configuration, as well as being configured to provide a second electrical signal between first electrode **90**B of IMD **16**A and second electrode **92**B to determine if IMD **16**A defines second fixation configuration.

[0095] In some examples, delivery device **50** may define holes in such a way that the holes are sealed within the delivery device. For example, as depicted in the conceptual diagram of FIG. **2**F illustrating a side view of delivery device **50** and FIG. **2**G depicting a cross-sectional view through cut plane **106**, deployment bay **52** may include one or more ribs **108** that extend in from outer wall **76** to engage IMD **16**A. Ribs **108** may be configured to be deformable to radially compress to secure IMD **16**A within deployment bay **52** prior to deployment. For example, ribs **108** may be made of a relatively soft and compressible biocompatible material, such as rubber, silicone, LDPE, thermoplastic elastomers, polyethylene (PE), or the like. Ribs **108** may extend longitudinally along a length of deployment bay **52**. Deployment bay **52** may define a plurality of ribs **108** at different longitudinal and radial locations. In some examples, deployment bay **52** may include a plurality of ribs **108** that are radially arranged around inner surface of outer wall **76** of deployment bay **52**. For example, as depicted deployment bay **52** may include four separate ribs **108** that are all equally spaced around longitudinal axis **60** of delivery device **50** at a shared longitudinal location within deployment bay **52** (e.g., such that each of ribs **108** is 90° away from a circumferentially adjacent rib **108**). In other examples, deployment bay **52** may include more or less ribs **108** that are radially arranged around longitudinal axis **60**,

such as three ribs **108** that are 120° away from each other, or five ribs **108** that are each approximately 72° away from circumferentially adjacent ribs **108**. Ribs **108** may be adhesively bonded or otherwise fixedly attached to an inner surface of outer wall **76** of deployment bay **52**.

[0096] Delivery device **50** may include one or more holes **86**B that are substantially similar to holes **86**A with the exception of any differences described herein. As depicted in FIGS. **2**F and **2**G, each of holes **86**B may be aligned with one of ribs **108**. Holes **86**B may radially extend in through both outer wall **76** and ribs **108**. Though FIG. **2**G depicts holes **86**B extending through only one of ribs **108**, in other examples holes **86**B may extend through more or all of ribs **108**.

[0097] As a result of ribs **108** extending in to engage IMD **16**A, holes **86**B are sealed against second electrode **92**B. As a result of ribs **108** sealing second electrode **92**B within deployment bay **52** such that second electrode **92**B is only exposed to fluid of patient when inserted in patient, circuitry **94** as discussed herein may identify more pronounced impedance changes as a result of deployment bay **52** defining a first fixation configuration as described herein. As a result of impedance changes being more pronounced, delivery device **50** may be relatively more likely to correctly determine when the deployment bay **52** is or isn't defining a fixation configuration, therein improving a likelihood that IMD **16**A is deployed in an efficacious manner.

[0098] Further, in some examples holes **86**A, **86**B (collectively, "holes **86**") may improve a manner in which deployment bay **52** is withdrawn from patient **14**. For example, as deployment bay **52** is withdrawn from patient **14** (e.g., following the deployment of IMD **16**A), distal opening **74** may create a relatively negative pressure within deployment bay **52** that pulls some fluid or tissue of patient into deployment bay **52**. Once deployment bay **52** is fully withdrawn out of patient **14** (e.g., through an introducer sheath or the like) this relatively negative pressure may stabilize, causing any fluid or tissue that has been pulled into deployment bay **52** to be leaked or ejected from deployment bay **52**. Holes **86** may improve an ability of pressure within deployment bay **52** to normalize (e.g., be relatively equal within and outside of deployment bay **52**) as deployment bay **52** is withdrawn from patient, therein reducing or elimination a vacuum effect that may pull fluid or tissue into deployment bay **52**. Reducing or eliminating this vacuum effect may reduce or eliminate the likelihood that deployment bay **52** gathers and then leaks and/or ejects patient **14** fluid or tissue as a result of withdrawing deployment bay **52** from patient **14**.

[0099] In some examples, delivery device **50** may be configured to verify when deployment bay **52** presses into tissue of a patient with a threshold amount of force. For example, as depicted in the conceptual diagram of FIG. **2**H illustrating a side view of delivery device **50**, deployment bay **52** may include first electrode **90**A within deployment bay **52** and second electrode **92**C at a distal tip of deployment bay **52**. First electrode **90**A may be secured to an inner surface of deployment bay **52** and/or a first electrode may be secured to IMD **16**A (e.g., such that first electrode **90**B is used with second electrode **92**C).

[0100] In some examples, second electrode **92**C may be "masked" with a non-conductive material **88** near the distal tip of the deployment bay **52**. Non-conductive material **88** may be any material that does not conduct electricity well. For example, non-conductive material **88** may include an adhesive that is applied to the outer surface of second electrode **92**C. The region of second electrode **92**C that is masked by non-conductive material **88** may include most or all of second electrode **92** that is immediately adjacent (e.g., within approximately 1 millimeter of) distal surface **80** of deployment bay **52**. Though region that is masked by non-conductive material **88** is depicted as masking an uneven portion of second electrode **92**C, in other examples a distal edge second electrode **92**C may be uniformly masked by non-conductive material **88**.

[0101] As a result of non-conductive material **88** masking second electrode **92**C, a conductive surface of second electrode **92**C may not contact tissue of a target site when deployment bay **52** initially contacts the tissue of the target site. Thus, when deployment bay **52** initially contacts but does press into tissue of the target site, the electrical signal may include fluid between first electrode **90**A and tissue of the target site and fluid between second electrode **92**C and tissue of the target site. If a clinician provides a further distal force on delivery device **50**, deployment bay **52** may press into tissue of the target site with sufficient force for the tissue to deform up around outer wall **76** of deployment bay **52** and contact a conductive surface of second electrode **92**C that is not masked by non-conductive material **88**. Thus, an electrical signal between first electrode **90**A and second electrode **92**C may include fluid between first electrode **90** and tissue and then tissue between this fluid and second electrode **92**C (e.g., and not include any fluid between second electrode **92**C and tissue). Circuitry **94** of delivery device **50** may be configured to identify when an impedance of the electrical signal changes as a result of a non-masked portion of second electrode **92**C contacting tissue of the target site. Where it is advantageous for deployment bay **52** to press into tissue with at least a threshold amount of force prior to deploying IMD **16**A, circuitry **94** may indicate when the impedance of the electrical signal rises above a threshold level that indicates this threshold amount of force such that deployment bay **52** defines a first fixation configuration.

[0102] In some examples, circuitry **94** of delivery device **50** may couple to a proximal portion of a metallic conductive can of IMD **16**A (e.g., the housing of IMD **16**A) to create a first electrode at a distal portion of IMD **16**A. For example, FIG. **2**I is a conceptual diagram illustrating an example first electrode **90**C comprised of the metal can of IMD **16**A and second electrode **92**D on elongated member **54** of delivery device **50**. Second electrode **92**D may be substantially similar to second electrodes **92**A, **92**B, **92**C with the exception of any differences described herein. Second electrode **92**D may be secured to an outer surface of a distal portion of elongated member **54** and may be configured to be exposed to fluid of patient **14** when deployment bay **52** is navigated to a target site. Further, delivery device **50** may include clamp **110** that includes teeth **112**. Clamp **110** may be configured to be slideable within deployment mechanism **66** of delivery device **50**. Specifically, clamp **110** may be configured to be longitudinally moveable within a lumen of deployment mechanism **66**, such that teeth **112** of clamp **110** may close down on proximal catch **114** of IMD **16**A. Teeth **112** may be actuatable (e.g., openable or closeable) as controlled by a clinician. For example, a clinician may actuate teeth **112** of clamp **110** open or close from a control mechanism for deployment mechanism **66** on or adjacent hub **56** as described above. Though clamp **110** is shown as

not engaging proximal catch **114** in FIG. **2**I for purposes of clarity, it is to be understood that clamp **110** may engage proximal catch **114** until IMD **16**A is verified (e.g., by circuitry **94**) as discussed herein to be securely fixed to the target site.

[0103] In some examples, clamp **110** and teeth **112** may be electrically coupled to a power source. For example, second electrode **92**D may be electrically coupled to a first terminal of a power source while clamp and teeth are electrically coupled to a second terminal of the same power source. As such when teeth **112** closes on proximal catch **114** of a metal can of IMD **16**A, the metal can may be electrically coupled to the second terminal of the power source, such that the metal can is first electrode **90**C.

[0104] In some examples, some or most of IMD **16**A may include coating **116**. Coating **116** may include an electrically insulative material. For example, some or most of IMD **16**A may be coated with coating **116** that includes a chemical-vapor-deposited material such as poly-para-xylylene, specifically Parylene. Part of coating **116** may be stripped away near proximal catch **114** and distal tip **96**. The amount of IMD **16**A that is covered by coating **116** is depicted for purposes only, as it is to be understood that more or less of IMD **16**A may be covered by coating **116** in other examples. In some examples, it may be advantageous to maximize an amount of IMD **16**A that is covered by coating **16**A to better electrically insulate IMD **16**A and therein potentially improve a battery life of power source of IMD **16**A.

[0105] Teeth **112** of clamp **110** may engage proximal end **100** proximal catch **114** to "light up" the metallic can of IMD **16**A (e.g., electrically couple can under insulative coating **116** to the power source). In this way, a surface of the metallic can near distal tip **96** of IMD **16**A acts as a first electrode **90**C as described herein, such that circuitry **94** may analyze impedance across a path between first electrode **90**C out of distal opening **74** of deployment bay **52** to second electrode **92**D on distal portion of elongated member **54**.

[0106] In some examples, as described herein, a second electrode may not be directly affixed to deliver device **50** but may instead by a patch electrode or a subcutaneous electrode or the like. For example, delivery device **50** may not include second electrode **92**D, but rather a second electrode may include a patch electrode on the skin of patient **14** or a subcutaneous electrode in a subcutaneous pocket of patient **14**. This second electrode may be a return electrode that is coupled to the power source. Circuitry **94** as described herein may calculate an impedance of an electrical signal between first electrode **90**C and this second electrode to verify if deployment bay **52** defines a fixation configuration.

[0107] FIG. **3** shows a schematic block diagram of circuitry **94** that may be used with any of the devices described herein to verify whether a deployment bay and/or an IMD defines a first and/or second fixation configuration as described herein as identified by sending and analyzing an electrical signal between a first and second electrode. Though FIG. **3** depicts circuitry **94** as a set of blocks for purposes of illustration, it is to be understood that circuitry **94** may include any number of current sources, regulators, oscillators, transistors, capacitors, or the like. Further, through circuitry **94** of FIG. **3** is primarily discussed below in relation to delivery device **50** and corresponding first electrode **90** and second electrode **92** as in FIG. **2**A for purposes of clarity, it is to be understood that circuitry **94** of FIG. **3** may additionally or alternatively be comprised within circuitry **28** of IMD **16**A in some examples. Circuitry **94** includes processing circuitry **120**, memory **122**, signal generation circuitry **124**, impedance detection circuitry **126**, indicating circuitry **128**, and power source **130**.

[0108] Processing circuitry **120**, may include any one or more microprocessors, controllers, digital signal processors (DSPs), application specific integrated circuits (ASICs), field-programmable gate arrays (FPGAs), discrete logic circuitry, or any processing circuitry configured to perform the features attributed to processing circuitry **120**. The functions attributed to circuitry described herein, including processing circuitry **120**, signal generation circuitry **124**, impedance detection circuitry **126**, and indicating circuitry **128**, may be provided by a hardware device and embodied as software, firmware, hardware, or any combination thereof.

[0109] Memory **122** may include any volatile or non-volatile media, such as a random-access memory (RAM), read only memory (ROM), non-volatile RAM (NVRAM), electrically erasable programmable ROM (EEPROM), flash memory, and the like. Memory **122** may store computer-readable instructions that, when executed by circuitry of circuitry **94**, cause circuitry **94** to perform various functions described herein. Memory **122** may be considered, in some examples, a non-transitory computer-readable storage medium including instructions that cause one or more processors, such as, e.g., processing circuitry **120**, to implement one or more of the example techniques described in this disclosure. The term "non-transitory" may indicate that the storage medium is not embodied in a carrier wave or a propagated signal. However, the term "non-transitory" should not be interpreted to mean that memory **122** is non-movable. As one example, memory **122** may be removed from delivery device **50** and moved to another device. In certain examples, a non-transitory storage medium may store data that can, over time, change (e.g., in RAM).

[0110] Processing circuitry **120** is configured to cause signal generation circuitry **124** to generate and deliver the electrical signal to tissue of patient **14** along path **132** between first electrode **90** and second electrode **92**. Signal generation circuitry **124** includes electrical signal generation circuitry such as a current source (e.g., a current mirror coupled to power source **130** and some transistors) and is configured to generate and deliver an electrical signal in the form of a known and/or constant voltage potential or current across first electrode **90** and second electrode **92** (e.g., such that, whatever the waveform of the electrical signal, signal generation circuitry **124** may compensate for impedance such that an amplitude of the electrical signal may remain consistent, though it may vary over time as intended in a predetermined manner). For example, the signal may include 100 microamps and may be between 8 kilohertz and 100 kilohertz.

[0111] In some examples, delivery device **50** may be configured such that conductors as described herein are independently coupled to one or more electrodes. For example, delivery device **50** may be configured to verify that distal surface **80** defining distal opening **78** of deployment bay **52** is defining a first fixation configuration with first electrode **90**A within recess **74** and second electrode **92**A secured to outer surface of outer wall **76** of deployment bay **52**. Additionally, delivery device **50** may be configured to verify that IMD **16**A is defining a second fixation configu-

ration with first electrode **90**B at distal tip **96** of IMD **16**A and an alternate second electrode **92**B on an outer surface of proximal portion **100** of IMD **16**A. In such examples, processing circuitry **120** may control signal generation circuitry **124** to generate and deliver different electrical signal via different combinations of conductors and/or electrodes (e.g., to an initial second electrode **92**A located outside of recess **74** and an alternate second electrode **92** on proximal portion **100** of IMD **16**A). In these examples, circuitry **94** may include a switching circuitry to switch the delivery of the electrical signal between different pairs of first and second electrodes **90**, **92** (e.g., switched as controlled by processing circuitry **120**).

[0112] Impedance detection circuitry **126** may be configured to identify and analyze an impedance of the electrical signal sent across path **132** between first electrode **90** and second electrode **92**. As described herein, an impedance may change depending upon a location of deployment bay **52** and IMD **16**A relative to tissue of the target site. For example, an impedance may increase when path **132** includes tissue rather than just fluid of patient **14**, and an impedance may reflect intrinsic waveforms of heart **12** with more or less noise and/or stability depending upon how well first electrode **90** is seated against tissue of the target site. Impedance detection circuitry **126** may be configured to isolate and identify this impedance.

[0113] Impedance detection circuitry **126** may identify impedance levels by including sample and hold circuitry to sample the voltage drop across the resistance. Using this voltage drop, impedance detection circuitry **126** may calculate the impedance. Impedance detection circuitry **126** may sample the voltage drop with a sampling rate that is sufficiently high enough to reliably identify the impedance signal. For example, impedance detection circuitry **126** may sample the voltage rate with a sampling rate around 1000 hertz.

[0114] Once impedance detection circuitry **126** determines an impedance, processing circuitry **120** may determine whether or not these impedance characteristics indicate that the deployment bay **52** and/or IMD **16**A define the first or second fixation configuration relative to tissue of the target site. Though processing circuitry **120** is discussed herein as analyzing "raw" or otherwise unmanipulated impedance data, it is to be understood that processing circuitry **120** may execute one or more operations prior to determining whether or not the impedance data indicates the first or second fixation configuration. For example, processing circuitry **120** may identify one or more derivatives of impedance data prior to and/or in addition to executing the functionality discussed herein. Being as derivatives may highlight any sudden changes in impedance data over time, the use of identifying and analyzing derivative data may improve an ability of processing circuitry **120** to identify fixation configurations and/or non-fixation configurations

[0115] For example, processing circuitry **120** may determine whether or not the electrical signal as generated and delivered by signal generation circuitry **124** to path **132** between first electrode **90** and second electrode **92** results in an impedance that is above impedance threshold **134** as stored in memory **122**. Impedance threshold **134** may include a static value where a momentary spike is sufficient for impedance detection circuitry **126** to determine that deployment bay **52** has defined a first fixation configuration. Alternatively, impedance threshold **134** may include an average impedance magnitude over a period of time (e.g., over 1 or two seconds).

[0116] Additionally, or alternatively, processing circuitry **120** may be configured to identify an amount that the current leads or lags the voltage across path **132** in order to identify a phase of heart **12** from the impedance. Processing circuitry **120** may identify whether or not the phase satisfies phase threshold **133** as stored in memory **122**. In some examples, processing circuitry **120** may be configured to determine whether the identified phase satisfies a plurality of phase thresholds **133** as relate to whether deployment bay **52** is generally contacting or pressing into tissue of a target site as discussed herein. Further, processing circuitry **120** may be configured to execute FFT on the electrical signal across path **132** to identify various frequency components as reflected in the impedance.

[0117] Where the impedance as detected by impedance detection circuitry **126** is above impedance threshold **134** and/or when phase as identified by processing circuitry **120** is above phase threshold **133**, processing circuitry **120** may cause indicating circuitry **128** to provide a first fixation configuration indication on user interface **104**. Indicating circuitry **128** may include components that can provide an output that is identifiable by a clinician as indicating a fixation or non-fixation configuration. For example, indicating circuitry **128** may include an LED (e.g., such as user interface **104** located on hub **56**), a speaker, a haptic feedback device, a screen or the like. Processing circuitry **120** may cause indicating circuitry to provide a predetermined output (e.g., green color on the LED, or a positive ding on the speaker, or a success message on the screen) in response to determining that an impedance indicated a fixation configuration. For another example, indicating circuitry **128** may include telemetry circuitry, and processing circuitry **120** may cause indicating circuitry **128** to provide a message for external device **18** of FIGS. **1**A and **1**B to display a successful first fixation configuration on a display of external device **18**.

[0118] For another example, circuitry **94** may be used to determine whether or not IMD **16**A defines a second fixation configuration. In such examples, processing circuitry **120** may cause signal generation circuitry **124** to provide a signal to path **132** between electrodes **90**, **92** that is similar or different than a signal (and/or path **132**, as described herein) used to determine if deployment bay **52** defines a first fixation configuration. Processing circuitry **120** may cause signal generation circuitry **124** to provide a second signal and/or cause impedance detection circuitry **126** to therein identify an impedance with which processing circuitry **120** determines if the second signal indicates that IMD **16**A defines a second fixation configuration in response to getting an input (e.g., from clinician) that specifically relates to verifying a second fixation configuration. Alternatively, processing circuitry **120** may cause signal generation circuitry **124** to generate a second signal and then cause impedance detection circuitry **126** to determine an impedance with which processing circuitry **120** determines whether the impedance of the second signal indicates a second fixation configuration automatically in response to impedance detection circuitry **126** identifying an impedance of a first signal that processing circuitry **120** determines is over impedance threshold **134** (such that deployment bay **52** defines a first fixation configuration). In some examples, processing cir-

cuitry **120** may cause signal generation circuitry **124** to provide an ongoing first signal and cause impedance detection circuitry **126** to continually determine a real-time impedance level in response to which processing circuitry **120** determines a real-time first fixation or non-fixation configuration. Processing circuitry **120** may cause signal generation circuitry **124** and impedance detection circuitry **126** to provide these ongoing functions and evaluations as signal generation circuitry **124** starts providing the second signal and processing circuitry **120** starts determining if an impedance of the second signal indicates a second fixation configuration (e.g., where different sets of conductors and electrodes provide the signal).

[0119] Processing circuitry **120** may determine whether or not the electrical signal as generated and delivered to first electrode **90** and second electrode **92** by signal generation circuitry **124** indicates that IMD **16**A defines a second fixation configuration by evaluating an amount of noise in the impedance waveform. Put differently, processing circuitry **120** determines whether or not an impedance waveform of the second signal across path **132** includes and/or satisfies one or more noise indicators **135**, or whether an impedance of the second signal is stable and smooth as described herein. Noise indicators **135** as stored in memory **122** and used by processing circuitry **120** include slope threshold **136**, bimodal signatures **137**, phase threshold **138**, and FFT threshold **139**.

[0120] Slope threshold **136** may include a threshold set of slopes that impedance may include or be within and be identified by processing circuitry **120** as defining a second fixation configuration. For example, a slope may satisfy slope threshold **136** where the slope is substantially smooth (e.g., linear or near-linear) between a peak and a valley of the impedance waveform, such that the slope substantially avoids defining steps, horizontal segments, sharp angles between the peak and the valley, or the like. FIGS. **8**A and **8**B and the discussion below depict and discuss slopes as may satisfy or fail slope threshold **136**. Processing circuitry **120** may determine that the impedance waveform as identified by impedance detection circuitry **126** satisfies slope threshold **136**, therein indicating that IMD **16**A defines second fixation configuration. In response to this determination, processing circuitry **120** may cause indicating circuitry **128** to indicate a second fixation configuration using user interface **104**.

[0121] Further, bimodal signatures **137** may include a mini-peak of an impedance waveform in an otherwise generally sinusoidal waveform (e.g., as depicted in FIG. **8**A). Processing circuitry **120** may determine that the impedance waveform including bimodal signatures **137** indicates that IMD **16**A defines second fixation configuration. In response to this determination, processing circuitry **120** may cause indicating circuitry **128** to indicate a second fixation configuration using user interface **104**.

[0122] Further, as discussed herein, processing circuitry **120** may identify an amount of noise of the signal by analyzing a relative lag of the current and voltage across path **132**. For example, processing circuitry **120** may identify and evaluate a phase of the impedance from the relative lag. Once identified, processing circuitry **120** may determine whether the phase is within phase thresholds **138**. Processing circuitry **120** may determine that the phase is within phase thresholds **138** if the waveform of the phase defines relatively static peaks and valleys across the waveform. For example, if each peak is substantially similar (e.g., within 0.2°) to the adjacent peak and each valley is substantially similar (e.g., within 0.2°) to the adjacent valley, the phase may be within phase thresholds **138**. Further, processing circuitry **120** may identify whether or not the phase waveform includes bimodal signatures **137** as discussed herein. If processing circuitry **120** determines that the phase waveform satisfies phase threshold **138** and fails to define bimodal signatures **137**, impedance detection circuitry may determine that the phase waveform indicates that IMD **16**A defines second fixation configuration. In response to this determination, processing circuitry **120** may cause indicating circuitry **128** to indicate a second fixation configuration using user interface **104**.

[0123] Additionally, as discussed herein, processing circuitry **120** may identify a component of the impedance using FFT. Processing circuitry **120** may use FFT to isolate the frequency components of the signal across path **132**. For example, processing circuitry **120** may identify a base frequency that corresponds to a heartbeat of patient **14** as well as a plurality of harmonic frequencies of the signal. Once identified, processing circuitry **120** may identify whether or not the amplitude of any of the identified harmonics satisfy FFT threshold **139** stored in memory **122**. FFT threshold **139** may relate to a ratio of the amplitude of one or more harmonic frequencies to the amplitude of the base frequency. For example, FFT threshold **139** may include a ratio between 1:5 and 1:3, such as 1:4, between the first harmonic (e.g., the harmonic with the largest amplitude) and the base frequency. Processing circuitry **120** may be configured to use this FFT threshold **139** of 1:4 to identify that determined FFT data indicates that IMD **16**A defines a fixation configuration (e.g., as a result of fixation elements **82** of IMD **16**A successfully securing to tissue of the target site) when the amplitude of the first harmonic is less than 25% of the amplitude of the base frequency. Similarly, processing circuitry **120** may using this FFT threshold **139** to identify that FFT data indicates that IMD **16**A defines a non-fixation configuration when the amplitude of the first harmonic is greater than 25% of the amplitude of the base frequency.

[0124] For another example, FFT threshold **139** may include a ratio between 1:3 and 2:3 between the sum of the amplitudes of the first two, three, or four harmonics (e.g., the **4** harmonics that have the four largest amplitudes) and the base frequency. In certain examples, FFT threshold **139** may include a ratio of 1:2 between the sum of the amplitudes of the first three harmonics and the base frequency. Processing circuitry **120** may be configured to use this FFT threshold **139** to identify that determined FFT data indicates that IMD **16**A defines a fixation configuration when the sum of the amplitudes of the first three harmonic is less than 50% of the amplitude of the base frequency. Similarly, processing circuitry **120** may using this FFT threshold **139** to identify that FFT data indicates that IMD **16**A defines a non-fixation configuration when the sums of the amplitudes of the first three harmonic is greater than 50% of the amplitude of the base frequency.

[0125] Though FFT of the impedance signal is discuss predominantly herein, other Fourier transforms and/or other transforms of other components into the frequency domain may be used in other examples to determine if the signal indicates a fixation or non-fixation configuration. For example, processing circuitry **120** may be configured to

analyze an electrogram from a lead inserted/implanted in right ventricle **22**, or a surface electrocardiogram from a surface patch, or left ventricle **26** pressure gathered from a pressure sensor inserted/implanted in left ventricle **26** using FFT techniques or other similar transforms. Upon transforming these data signals into a frequency domain, processing circuitry **120** may identify whether certain frequency components of these signals have a magnitude that is greater than a threshold (e.g., where a magnitude above a threshold is included in noise indicators **135** of memory **122** of circuitry **94**) and may thus determine that one or more components of a signal that is delivered or otherwise captured or identified by delivery device **50** are defining non-fixation configuration **150** as a result of the frequency components defining the magnitude greater than the threshold.

[0126] In some examples, circuitry **94** may be configured to determine and indicate single momentary configuration arrangements of deployment bay **52** and IMD **16**A relative to tissue of the target site. For example, processing circuitry **120** may cause signal generation circuitry **124** to create a voltage potential across first electrode **90** and second electrode **92** for a time period that is sufficient for processing circuitry **120** to determine and analyze an impedance of the electrical signal as delivered across path **132**, in response to which processing circuitry **120** may cause signal generation circuitry **124** to cease the voltage potential (as well as causing indicating circuitry **128** to provide an indication of the configuration to user interface **104**). For example, processing circuitry **120** may cause signal generation circuitry **124** to provide a signal for between 1 and 5 seconds, a duration which may provide indicative average values. In such an example, a clinician may provide an input (e.g., using user interface **104** and/or programmer **18** or the like) to circuitry **94**, in response to which circuitry may provide a single configuration analysis (e.g., deployment bay **52** defining first fixation configuration, IMD **16**A defining second fixation configuration, none of delivery device **50** in any fixation configuration). Put differently, in some examples circuitry **94** may be configured to provide "snapshots" of immediate and momentary spatial alignments of the delivery device **50** and tissue of the target site.

[0127] In other examples, circuitry **94** may be configured to determine and indicate changing configuration information over time. For example, processing circuitry **120** may cause signal generation circuitry **124** to create an ongoing and substantially static voltage potential across first electrode **90** and second electrode **92**, such that impedance detection circuitry **126** identifies an ongoing impedance with which processing circuitry **120** provides an ongoing analysis of the ongoing impedance of the ongoing electrical signal as delivered across path **132**. As a result of this, processing circuitry **120** may control indicating circuitry **128** to cause user interface **104** to provide changing fixation configurations over time in response to impedance updates from impedance detection circuitry **126**. In such an example, a clinician may provide an initial input (e.g., using user interface **104** and/or external device **18** or the like) to circuitry **94** to start providing ongoing fixation configuration indications, in response to which circuitry **94** may continue providing indications until the clinician instructs circuitry **94** to stop providing fixation configuration indications. For example, a clinician may provide an initial input to start providing fixation indications, in response to which signal generation circuitry **124** may deliver an electrical signal to path **132** between first electrode **90** and second electrode **92**, in response to which processing circuitry **120** may initially determine that an impedance detected by impedance detection circuitry **126** is below impedance threshold **134**, in response to which indicating circuitry **128** may cause user interface **104** to indicate a failure to define first fixation configuration (e.g., by causing an LED to display a red light), in response to which a clinician may move deployment bay **52** against tissue of target site, in response to which processing circuitry **120** may determine that impedance of the electrical signal across path **132** as identified by impedance detection circuitry **126** has changed to be above impedance threshold **134**, in response to which indicating circuitry **128** may cause user interface **104** to indicate a first fixation configuration (e.g., such a green light), in response to which a clinician may deploy IMD **16**A, in response to which processing circuitry **120** may determine that impedance waveforms of a signal across path **132** do not include bimodal signatures **137**, in response to which indicating circuitry **128** may cause user interface **104** to indicate a second fixation configuration (e.g., such as a blue light), in response to which the clinician may provide an input to circuitry **94** to cease delivering the electrical signal to path **132** between first electrode **90** and second electrode **92**.

[0128] Power source **130** delivers operating power to various components of circuitry **94**. In some examples, power source **130** may represent a hard-wired electrical supply of alternating or direct electrical current. In other examples, power source **130** may include a small rechargeable or non-rechargeable battery and a power generation circuitry to produce the operating power. Where power source **130** is rechargeable, recharging may be accomplished through proximal inductive interaction between an external charger and an inductive charging coil coupled to power source **130**.

[0129] In some examples, as conceptually depicted, processing circuitry **120**, memory **122**, signal generation circuitry **124**, impedance detection circuitry **126**, indicating circuitry **128**, and power source **130** may all be directly physically coupled to each other and to electrodes **90**, **92** through a physical medium (e.g., wires or vias or traces or the like). Further, in some examples, each of processing circuitry **120**, memory **122**, signal generation circuitry **124**, impedance detection circuitry **126**, indicating circuitry **128**, and power source **130** may be housed within a single enclosure, such as a hermetically sealed housing of IMD **16**A or in hub **56** of delivery device **50** or the like. In other examples, different elements of circuitry **94** may be housed in two or more enclosures, and may communicate using a variety of physical (e.g., wired) connections and wireless communication protocols.

[0130] For example, IMD **16**A may include some signal generation circuitry **124**, impedance detection circuitry **126**, power source **130** to power signal generation circuitry **124** and impedance detection circuitry **126**, and some processing circuitry (e.g., processing circuitry that is similar but less powerful than processing circuitry **120**) that is configured to cause signal generation circuitry **124** to create an electrical signal to path **132** between electrodes **90**, **92** and cause impedance detection circuitry **126** to detect an impedance of the signal across path **132**. In this example, this processing circuitry **120** may further be configured use telemetry circuitry (not depicted) to send the impedance data as detected

by impedance detection circuitry **126** to another device that includes processing circuitry **120**, memory **122**, and indicating circuitry **128**. For example, IMD **16**A may send impedance data to another device that is external to IMD **16**A (e.g., such as external device **18**) that may include processing circuitry **120**, memory **122**, and indicating circuitry **128**, in response to which the another device may analyze the impedance data and verify whether or not deployment bay **52** and/or IMD **16**A defines first or second fixation configurations as described herein.

[0131] FIGS. **4**A and **4**B are conceptual diagrams illustrating views as taken along longitudinal axis **60** of delivery device **50** as not defining and then defining, respectively, a first fixation configuration relative to target site **140** in patient **14**. FIGS. **4**A and **4**B are depicted without IMD **16**A for purposes of clarity, as first fixation configuration is between deployment bay **52** and tissue of target site **140**. As described herein, target site **140** may be in right atrium **20** of heart **12** of patient **14**, though delivery device **50** may be used to delivery an implantable medical device to other areas of patient **14** in other examples. Target site **140** may include layer of tissue **142** to which IMD **16**A is configured to pierce during deployment in order to secure IMD **16**A to the target site **140**. Put differently, in some examples IMD **16**A is configured to mechanically attach itself to tissue layer **142** of target site **140**. IMD **16**A may be configured to secure itself to tissue layer **142** using fixation element **82** such as distal tines some other fixation means (e.g., helical coil) that are configured to distally extend from deployment bay **52** when IMD **16**A is deployed (e.g., using deployment mechanism **66** of FIGS. **2**A and **2**B that distally pushes IMD **16**A out of distal opening **78** of deployment bay **52**). Further, in some examples, target site **140** may include muscle layer **144** that is beneath tissue **142** from the reference of delivery device **50**, i.e., further away from delivery device **50** than tissue **142**.

[0132] As depicted in FIG. **4**A, a clinician has navigated delivery bay **52** of delivery device **50** to target site **140**, such that IMD **16**A (not depicted in FIG. **4**A) as housed at least partially within deployment bay **52** is adjacent target **140**. Deployment bay **52** may be navigated proximal to target site **140** as a result of a distal force **146** applied to delivery device **50**. A clinician may apply distal force **146** by, e.g., manually applying a force to one or more proximal components of delivery device **50**. For example, a clinician may apply distal force **146** to hub **56** (depicted in FIG. **2**A), or otherwise apply distal force **146** using hub **56**.

[0133] As depicted in FIG. **4**A, deployment bay **52** may contact tissue **142** at target site **140** as a result of distal force **156** (e.g., as applied by clinician). Deployment bay **52** may contact tissue **142** at angle **148** relative to longitudinal axis **60** of delivery device **50**. Put differently, FIG. **4**A depicts distal surface **80** that defines distal opening **78** of deployment bay **52** defining angle **148** with a surface of target site **140** (e.g., rather than the two surfaces being flush or parallel with each other). As a result of approaching target site **140** at angle **148**, deployment bay **52** may define path **132**A (which may be substantially similar to path **132**) between first electrode **90**A and second electrode **92**A. As depicted in FIG. **4**A, path **132**A initially extends substantially only through fluid (e.g., rather than tissue **142**) of patient **14** as a result of deployment bay **52** contacting tissue **142** at angle **148**. If delivery device **50** deploys IMD **16**A when distal surface **80** that defines distal opening **78** of deployment bay **52** is at angle **148** to target site **140**, tines or fixation elements **82** of IMD **16**A may have difficulty fixating to target site **140** as intended. For example, tines or fixation elements **82** of IMD **16**A that are close to a side of deployment bay **52** that is contacting tissue **142** may secure to muscle **144**, while tines or fixation elements opposite side **162** may not successfully secure to any tissue **142** of target site **140**.

[0134] A clinician may provide a prompt to circuitry **94** to send electric signal to path **132**A between first electrode **90**A and second electrode **92**A. The depicted location of first electrode **90**A and second electrode **92**A in FIG. **4**A is for purposes of illustration only, as both first electrode **90**A and second electrode **92**A may be at different locations and/or may be secured to or otherwise part of other components in other examples. For example, in some situations first electrode **90**A may be a distal electrode on distal tip **96** of IMD **16**A as described herein. For another example, in some cases first and/or second electrodes **90**A, **92**A may not extend fully around an inner or outer surface of deployment bay **52**, respectively, but may only occupy a discrete circumferential portion of an inner or outer surface of deployment bay **52**.

[0135] The clinician may provide the prompt to circuitry **94** in order to test if deployment bay **52** is defining the first fixation stage relative to tissue **142**. The clinician may provide the prompt in response to detecting that deployment bay **52** has approached tissue **142** of target site **140**. The clinician may detect that deployment bay **52** has approached tissue **142** of target site **140** by tracking one or more radiopaque elements (not depicted) secured to or adjacent deployment bay **52**. In some examples, first electrode **90**A and/or second electrode **92**A may function as radiopaque elements. The clinician may provide the prompt to start testing using external device **18** or using user interface **104** on hub **56** or using some other input mechanism. In some examples, the clinician may provide a specific input to use first electrode **90**A within deployment bay **52** and second electrode **92**A outside of deployment bay **52** to test whether deployment bay **52** defines a first fixation configuration relative to tissue **142** of target site **140** (e.g., rather than testing whether or not IMD **16**A defines a second fixation configuration relative to tissue **142** of target site **140**).

[0136] Processing circuitry **120** may receive the input from the clinician and cause signal generation circuitry **124** to generate the signal along path **132**A. Signal generation circuitry **124** may use conductors **102** that extend longitudinally through delivery device **50** to create a relatively static voltage potential across first and second electrodes **90**A, **92**A. It is to be understood that the depiction of conductors **102** within FIG. **4**A (and also FIG. **4**B) is for purposes of illustration only. Processing circuitry **120** may detect that impedance across path **132**A as detected by impedance detection circuitry **126** is below impedance threshold **134** as a result of path **132**A containing entirely fluid of patient **14**. As such, processing circuitry **120** may detect that deployment bay **52** is defining non-fixation configuration **150**A relative to tissue **142** of target site **140**. Processing circuitry **120** may cause indicating circuitry **128** to provide an indication (e.g., using user interface **104**) that deployment bay **52** is in non-fixation configuration **150**A.

[0137] In response to the clinician noticing user interface **104** (e.g., as displayed on external device **18**) indicating non-fixation configuration **150**A, the clinician may navigate or otherwise manipulate or deflect deployment bay **52** relative to tissue **142** of target site **140**. For example, as

depicted in the conceptual view along longitudinal axis **60** of FIG. **4**B, the clinician may control delivery device **50** (e.g., using one or more steering or movement or deflection mechanisms of hub **56**) to cause deployment bay **52** to define first fixation configuration **152**A relative to tissue **142** of target site **140**. First fixation configuration **152**A may include surface **80** that defines distal opening **78** of deployment bay **52** being substantially and/or entirely flush against tissue **142** of target site **140**. Put differently, first fixation configuration **152**A may include longitudinal axis **60** of delivery device **50** and therein deployment bay **52** being normal to (at a substantially right angle to) a surface defined by tissue **142** of target site **140**.

[0138] As discussed herein, circuitry **94** may detect and verify when deployment bay **52** defines first fixation configuration **152**A relative to tissue **142** of target site **140**. For example, as discussed herein, processing circuitry **120** may cause signal generation circuitry **124** to generate an electrical signal across path **132**A between first electrode **90**A and second electrode **92**A. As depicted in FIG. **4**B, path **132**A may include some tissue **142** when deployment bay **52** defines first fixation configuration **152**A relative to tissue **142** of target site **140**. Processing circuitry **120** may detect that an impedance detected by impedance detection circuitry **126** has raised above impedance threshold **134** (e.g., as a result of path **132**A including tissue **142** of patient **14**. In response to processing circuitry **120** detecting that the impedance of path **132**A has raised above impedance threshold **134**, processing circuitry **120** may cause indicating circuitry **128** to provide an indication using user interface **104** that deployment bay **52** is defining first fixation configuration **152**A.

[0139] In some examples, circuitry **94** may generate an ongoing electrical signal on path **132**A and may therein provide an ongoing indication as to whether or not deployment bay **52** is defining first fixation configuration **152**A. For example, in response to processing circuitry **120** determining that impedance of path **132**A was below impedance threshold **134** in FIG. **4**A as a result of deployment bay **52** defining non-fixation configuration **150**A, processing circuitry **120** may cause indicating circuitry **128** to provide an ongoing indication of non-fixation configuration **150**A. Processing circuitry **120** may cause indicating circuitry **128** to provide an ongoing indication until processing circuitry **120** receives input from a clinician to cease providing an indication. If processing circuitry **120** detects that impedance of path **132**A as detected by impedance detection circuitry **126** rises above impedance threshold **134** (e.g., as in FIG. **4**B), processing circuitry **120** may cause indicating circuitry **128** to provide a different ongoing indication indicating first fixation configuration **152**A. In this way a clinician may receive an ongoing indication as to whether deployment bay **52** is stably defining first fixation configuration **152**A (e.g., when deployment bay **52** defines first fixation configuration **152**A for two second straight as indicated on user interface **104**), and therein the clinician may deploy IMD **16**A in response to deployment bay **52** stably defining first fixation configuration **152**A. By configuring circuitry **94** to determine and indicate an ongoing and real-time (e.g., substantially instantaneous) fixation status of deployment bay **52**, circuitry **94** may improve an ability of delivery device **50** to deploy IMD **16**A in an efficacious fixation alignment as discussed herein.

[0140] In some examples, first fixation configuration **152**A may include surface **80** that defines distal opening **78** contacting tissue **142**, such that delivery device **50** is efficaciously arranged to deploy IMD **16**A as soon as surface **80** contacts tissue **142**. Put differently, in such examples, as soon as substantially all of distal surface **80** contacts tissue **142**, deployment bay **52** may define first fixation configuration **152**A. In other examples, first fixation configuration **152**A may include surface **80** that defines distal opening **78** pressing against tissue **142** of target site, such that delivery device **50** is efficaciously arranged to deploy IMD **16**A as soon as surface **80** presses into tissue **142**. Distal surface **80** of deployment bay **52** may press against tissue **142** as a result of distal force **146**. Distal surface **80** may press into tissue **142** with enough force to momentarily deflect and/or deform tissue **142** but not penetrate or otherwise damage tissue **142**. Whether first fixation configuration **152**A includes contacting or pressing into tissue **142** may relate to the manner in which fixation elements **82** of IMD **16**A are deployed from deployment bay **52** to become secured to tissue **142** of target site **140**. For example, in some situations fixation elements **82** may be configured such that fixation elements **82** may be relatively more likely to secure IMD **16**A according to a preferred manner when surface **80** initially contacts tissue **142**. Alternatively, in other situations fixation elements **82** may be configured such that fixation elements **82** are relatively more likely to secured IMD **16**A in a preferred manner when surface **80** presses against tissue **142**. In either situation, circuitry **94** may be configured to verify when distal surface **80** defines such fixation configuration.

[0141] For example, an impedance of an electrical signal across path **132**A may be relatively lower as a result of distal surface **80** being flush with (rather than being pressed against) tissue **142** of target site **140**. The impedance may be relatively lower as a result of slight deviations (e.g., non-flat features) in the surface of tissue **142** that define small channels between surface **80** and tissue **142** through which a small amount of fluid may pass (e.g., because surface **80** is not pressing against tissue **142** to deform tissue **142** and therein effectively eliminate the presence of such channels). As such, where fixation elements **82** and IMD **16**A are configured such that IMD **16**A is more likely to be efficaciously secured when distal surface **80** contacts (rather than presses against) tissue **142**, impedance threshold **134** as stored within memory **122** and utilized by processing circuitry **120** may be relatively lower. Similarly, where fixation elements **82** and IMD **16**A are configured such that IMD **16**A is more likely to be efficaciously secured when distal surface **80** presses against (rather than merely is flush with) tissue **142**, impedance threshold **134** as stored within memory **122** and utilized processing circuitry **120** may be relatively higher.

[0142] Further, as discussed herein, circuitry **94** may be configured to detect and verify when and/or whether IMD **16**A defines a second fixation configuration relative to tissue **142** of target site **140** upon IMD **16**A being deployed. For example, FIGS. **5**A-**5**D depict conceptual illustrations of IMD **16**A being deployed from deployment bay **52** at target site **140**. Though FIGS. **5**A-**5**D are depicted with outer wall **76** of deployment bay **52** being transparent to depict IMD **16**A for purposes of illustration, it is to be understood that in some examples outer wall **76** of deployment bay **52** may not be transparent. Circuitry **94** may generate an electrical

signal to be sent through tissue **142** and fluid of patient **14** along path **132**B (which may be substantially similar to path **132** and path **132**A with the exception of any differences described herein) between first electrode **90**B and second electrode **92**B. As depicted, first electrode **90**B may be secured to distal tip **96** of IMD **16**A, while second electrode **92**B includes a band that runs around at least a part of an outer perimeter of IMD **16**A. First electrode **90**B may be substantially similar to first electrode **90** and first electrode **90**A, and second electrode **92**B may be substantially similar to second electrode **92** and second electrode **92**B

[0143] FIGS. **5**A-**5**D depict fixation elements **82**A, **82**B (collectively, "fixation elements **82**") deploy from deployment bay **52** to secure IMD **16**A to tissue **142**. As depicted in FIGS. **5**A-**5**D, fixation elements **82** may include tines. Fixation elements **82** include two tines that are mirrored across electrode **90**B in FIGS. **5**A-**5**D for purposes of clarity, but more or less fixation elements **82** may be included in other examples. For example, IMD **16**A may include three, four, or more tine fixation elements **82** that are arranged around first electrode **90**B in a circular arrangement on distal tip **96** of IMD **16**A, or IMD **16**A may include a single helical coil that wraps around electrode **90**B as the helical coil extends distally from distal tip **96** of IMD **16**A. Fixation elements **82** that include tines may comprise distal ends that are configured to extend into tissue **142** and then curl back proximally out of tissue **142** toward IMD **16**A. However, in other examples fixation elements **82** may include tines that operate differently, or fixation elements **82** may include distal helical coils or the like. Fixation elements **82** may be configured to secure IMD **16**A to tissue **142** such that first electrode **90**B contacts tissue **142**. Further, fixation elements **82** may be configured to provide a forward pressure onto electrode **90**B such that electrode **90**B presses into tissue **142** to assure proper electrode-tissue contact.

[0144] As depicted in FIG. **5**A, deployment bay **52** may contact tissue **140** at an angle (e.g., an angle similar to angle **148** of FIG. **4**A) such that surface **80** of deployment bay **52** is not flush with tissue **142**. As a result of surface **80** not being flush with tissue **142**, deployment bay **52** may define non-fixation configuration **150**A relative to tissue **140**. In some examples, deployment bay **52** may define non-fixation configuration **150**A as a result of a clinician not testing if deployment bay **52** defines first fixation configuration **152**A (e.g., as a result of delivery device **50** not being configured to test if deployment bay **52** defines first fixation configuration **152**A). Alternatively, deployment bay **52** may have previously defined first fixation configuration **152**A as determined by circuitry **94** and indicated to a clinician using user interface **104**, after which deployment bay **52** and/or tissue **142** may have moved relative to each other as IMD **16**A was deployed.

[0145] As depicted in FIG. **5**A, fixation elements **82** may extend distally out of distal opening **78**. Fixation elements **82** may extend distally out of distal opening **78** as a result of pushing element **68** pushing IMD **16**A distally within deployment bay **52**. Where deployment bay **52** defines non-fixation configuration **150**A, some of fixation elements **82** may not fully engage tissue **142** as fixation elements **82** extend distally from deployment bay **52**. For example, as depicted, fixation element **82**A may extend into tissue **142** while fixation element **82**B does not contact/engage tissue **142**. In some cases, as discussed above, fixation element **82**A close to tissue **142** when IMD **16**A is deployed may pierce muscle **144** (e.g., as depicted in FIGS. **4**A and **4**B) of target site **140**, though such piercing is not depicted in FIGS. **5**A and **5**B for purposes of clarity. As depicted in FIG. **5**B, fixation elements **82** may pull electrode **90**B in contact with tissue **142**. Upon some or all fixation elements **82** engaging tissue **142**, a clinician may partially proximally retract deployment bay **52** and delivery device **50** to test a fixation of IMD **16**A.

[0146] For example, as discussed herein, a clinician may attempt a tug test, where a clinician tugs on a proximal end of IMD **16**A to verify that IMD **16**A is securely attached to tissue **142**. A clinician may use a longitudinal member that engages a proximal end of IMD **16**A to execute a tug test. For example, IMD **16**A may include proximal catch **114** that extends proximally from IMD **16**A and may be engaged with tether **162** of delivery device **50**. Tether **162** may be configured to engage an aperture of proximal catch **114** as depicted in FIGS. **5**A-**5**D. Tether **162** may be configured to move within delivery device **50**. For example, tether **162** may be configured to be slideable within a deployment mechanism (e.g., such as deployment mechanism **66** of FIGS. **2**A and **2**B) of delivery device **50** and operable from hub **56** of delivery device **50**. A clinician may tug on IMD **16**A by tugging on tether **162** that is engaged with catch **114**.

[0147] However, tissue **142** of target site **140** may be too thin for a clinician to visually identify if fixation elements **82** are secured to tissue **142**. For example, where target site **140** is in right atrium **20**, tissue **142** may be between 2 to 3 millimeters (mm) thick, such that where fixation elements **82** are attempting to avoid muscle **144** behind tissue **142** fixation elements may only extend 1 or 2 mm into tissue **142**. As such, depending upon an angle of IMD **16**A and tissue **142** of target site **140**, it may be difficult or impossible to see if fixation elements **82** have engaged any of tissue **142** upon deployment.

[0148] Therefore, as discussed herein, a clinician may use circuitry **94** to verify if IMD **16**A defines a second fixation configuration relative to tissue **142**. Circuitry **94** may generate an electrical signal to path **132**B (which may be substantially similar to path **132** and path **132**A with the exception of any differences discussed herein) between first electrode **90**B and second electrode **92**B. In some examples, circuitry of IMD **16**A (e.g., circuitry **28** of FIG. **1**A) may comprise some or all of circuitry **94**.

[0149] Circuitry **94** may include processing circuitry **120** that causes signal generation circuitry **124** to generate the electrical signal. As discussed herein, the electrical signal can be transmitted by generating a voltage potential across first electrode **90**B and second electrode **92**B. Processing circuitry **120** may analyze an impedance of the electrical signal on path **132**B between first and second electrodes **90**B, **92**B that is detected by impedance detection circuitry **126**. For example, where tissue **142** is tissue **142** of heart **12**, impedance as detected by impedance detection circuitry **126** may include and/or reflect one or more intrinsic waveforms of heart **12**. Processing circuitry **120** may detect whether these one or more impedance waveforms of electrical signal as impacted by heart **12** are stable, or whether impedance waveforms have more than a threshold amount of noise (e.g., as determined by the presence of bimodal signatures **137** as stored in memory **122** of circuitry **94** from FIG. **3**). The waveforms as reflected in impedance may be stable as a result of how well engaged first electrode **90**A is with tissue **142** of heart **12** (as a result of fixation elements **82**

engaging tissue **142**). For example, electrode **90**A may be engaged with tissue **142** of heart **12** sufficiently when a threshold amount of fixation elements **82** engage tissue **142** (e.g., at least two circumferentially adjacent fixation elements **82** of four fixation elements **82** that surround first electrode **90**A in a circular arrangement, or at least 75% of helical screws of a single distal screw that extends from a respective IMD).

[0150] In some examples, processing circuitry **120** may detect that the impedance waveform of the electrical signal includes bimodal signatures **137** and therein indicate that IMD **16**A defines non-fixation configuration **150**B relative to tissue **142**. In some examples, processing circuitry **120** may detect that the impedance waveform includes bimodal signatures **137** while a clinician executes a tug test. For example, a tug test may exacerbate or make pronounced any errors or shortcomings of the fixation of IMD **16**A to tissue **142**. By testing path **132**B between electrodes **90**B, **92**B while a clinician is tugging on proximal catch **114** using tether **162**, a clinician may increase an ability of circuitry **94** to determine whether or not IMD **16**A is deployed such that IMD **16**A defines a second fixation configuration relative to tissue **142**.

[0151] In response to processing circuitry **120** detecting that an impedance waveform includes bimodal signatures **137**, processing circuitry **120** may cause indicating circuitry **128** to provide indication on user interface **104** of second non-fixation configuration **150**B. A clinician may see this indication of non-fixation configuration **150**B of IMD **16**A relative to tissue **142** and therein decide to retract **16**A fully back into deployment bay **52** to redeploy IMD **16**A. Delivery device **50** may include any of a plurality of retraction mechanism to retract IMD **16**A into deployment bay **52** once fixation elements **82** are deployed from deployment bay **52** are partially affixed to tissue **142**. For example, a clinician may pull on tether **162** to remotely pull IMD **16**A back into deployment bay **52**. Pulling IMD **16**A back into deployment bay **52** may release IMD **16**A from patient tissue **142** and returns IMD **16**A to the position shown in FIG. **2**A. For example, pulling IMD **16**A back into deployment bay **52** may return fixation elements **82** back from the deployed position (where the distal ends of fixation elements **82** extend proximally back towards IMD **16**A) into a deployable position (where the distal ends of fixation elements **82** extend distally from IMD **16**A). From this position, a clinician may reposition IMD **16**A as desired and redeploy IMD **16**A.

[0152] For example, as depicted in FIG. **5**C, deployment bay **52** may be repositioned relative to tissue **142**. Deployment bay **52** may be positioned into first fixation configuration **152**A. For example, a clinician may use electrodes and circuitry **94** of delivery device **50** to verify that distal surface **80** the defines distal opening **78** of deployment bay **52** is flush with tissue **142**. Circuitry **94** may verify that the impedance of the electrical signal provided across a path (e.g., path **132**A) is over impedance threshold **134** before processing circuitry **120** causes indicating circuitry **128** to provide indication of first fixation configuration **152**A to user interface **104**.

[0153] Once deployment bay **52** defines first fixation configuration **152**A relative to tissue **142**, IMD **16**A may be pushed distally (e.g., using pushing element **68**) such that fixation elements **82** extend distally out of deployment bay **52** and engage tissue **142** as depicted in FIG. **5**C. Once fixation elements **82** extend distally out of deployment bay **52** to engage tissue **142**, fixation elements **82** may be configured to push IMD **16**A distally to secure IMD to tissue **142**. In other examples, fixation elements **82** may have to be manually secured to tissue **142**.

[0154] In response to fixation elements **82** deploying IMD **16**A from deployment bay **52**, delivery device **50** may verify whether or not IMD **16**A is in a second fixation configuration relative to tissue **142**. For example, as described above, circuitry **94** may generate an electrical signal across path **132**B and identify if impedance waveforms are stable (e.g., stable through a tug test) or if impedance waveforms include bimodal signatures **137**. Where first electrode **90**A is pressed into tissue **142** sufficiently as depicted in FIG. **5**D, impedance waveforms may be relatively stable and may have little or no noise indicators **135**, such that internal processing **94** may identify that IMD **16**A defines second fixation configuration **152**B relative to tissue **142**. In some examples, as described herein, a clinician may perform one or more tug tests while circuitry **94** is providing the electrical signal to electrodes **90**B, **92**B as well as when circuitry **94** is verifying that IMD **16**A defines second fixation configuration **152**B. For example, a clinician may initially wait for a few seconds (e.g., approximately 5 seconds) before starting a tug test, and then a clinician may maintain the pressure on tether **162** for a few second (e.g., approximately 5 seconds) to improve an ability of circuitry **94** to gather an adequate baseline for comparison. In response to IMD **16**A defining second fixation configuration **152**, processing circuitry **120** of circuitry **94** may provide an indication of a successful second fixation configuration **152**B using user interface **104** to a clinician.

[0155] As shown in FIG. **5**D, once IMD **16**A is secured to patient tissue **142** in second fixation configuration **152**B, the clinician may release IMD **16**A from tether **162**. For example, the clinician may sever tether **162** at a port in hub **56** of delivery device **50** and remove tether **162** from delivery device **50** by pulling on one of the severed ends of tether **162**. As shown in FIG. **5**D, once IMD **16**A is released from tether **162**, the clinician may remove delivery device **50**, leaving IMD **16**A secured to patient tissue **142**.

[0156] FIG. **6** is a chart of example impedance data **114** as may be identified by processing circuitry **120** as indicating first fixation configuration **152**A. It is to be understood that impedance data **114** provided in FIG. **6** is provided for purposes of illustration only, as other systems may alter impedance values and similar systems may generate different impedance values depending upon medical conditions of patient **14**. As depicted, impedance data **114** may cover testing over multiple stages. For example, first stage **162** includes impedance data **114** of an electrical signal across path **132** that included substantially only fluid of patient **14** (e.g., such as FIG. **4**A). Further, second stage **164** includes impedance data **114** of an electrical signal across path **132** when distal opening **80** of deployment bay **52** is flushly contacting but not pressing against tissue **142**. Lastly, third stage **166** includes impedance data **114** of an electrical signal across path **132** when distal opening of deployment bay **52** is both flush with and pressing against tissue **142** of target site **140**. As will be understood by one of ordinary skill in the art, oscillations in the signal as indicated in FIG. **6** (as well as FIG. **7**-FIG. **9**B) represent movement and activity of heart **12** during the cardiac cycle as picked up by electrodes **90**, **92**.

[0157] As depicted, impedance data **114** may increase in magnitude as deployment bay **52** contacts and then presses up against tissue **142** of target site **140**. For example, impedance data **114** may initially hold relatively steady around 350Ω during first stage **162**, after which impedance data **114** may fluctuate between around 400Ω and 370Ω during second stage **164**, after which impedance data **114** may fluctuate between approximately 405Ω and 440Ω in third stage **166**. In this example, circuitry **94** may use impedance threshold **134** of around 370Ω where first fixation configuration **152**A includes merely contacting tissue **142** of target site **140** flush, or circuitry **94** may use impedance threshold **134** of around 400Ω where first fixation configuration **152**A includes pressing into tissue **142**. Alternatively, circuitry **94** may include impedance threshold **134** of impedance data **114** increasing in value between 100% and 150% above impedance data **114** of first stage **162**. Other examples are also possible.

[0158] FIG. **7** is a chart of example phase data **168** as may be identified by impedance detection circuitry **126** and as determined by processing circuitry **120** to indicate first fixation configuration **152**A. For example, as discussed herein, phase data **168** may be identified by monitoring the angle that the voltage leads or lags the current. It is to be understood that phase data **168** provided in FIG. **7** is provided for purposes of illustration only, as other systems may capture slightly different phase values and similar systems may capture different phase values depending upon medical conditions of patient **14**. As depicted, phase data **168** may cover testing over multiple stages, similar to the chart of FIG. **6** as discussed above (e.g., where first stage **162** includes phase data **168** when path **132** includes substantially only fluid, second stage **164** includes phase data **168** when distal opening **80** is flush against tissue **142**, and third stage **166** includes phase data **168** when distal opening of deployment bay **52** is pressing against tissue **142**).

[0159] As depicted, phase data **168** may increase in magnitude as deployment bay **52** contacts and then presses up against tissue **142** of target site **140**. For example, phase data **168** may initially fluctuate between 11° and 11.5° during first stage **162**, after which phase data **168** may increase in range and fluctuate between around 11° and 12° during second stage **164**, after which phase data **168** may fluctuate between approximately 12° and 13° in third stage **166**. In this example, circuitry **94** may use phase threshold **133** of around 11.6° where first fixation configuration **152**A includes merely contacting tissue **142** of target site **140** flush, or circuitry **94** may use phase threshold **133** of around 12.5° where first fixation configuration **152**A includes pressing into tissue **142**. Alternatively, circuitry **94** may include phase threshold **133** of a percentage increase (e.g., an increase of an average value of phase data **168** of first stage **162** of between 5% and 20%). Other examples are also possible.

[0160] FIG. **8**A is a chart of example impedance data **170**A as may be identified by impedance detection circuitry **126** and determined by processing circuitry **120** to indicate second non-fixation configuration **150**B. It is to be understood that impedance data **170**A provided in FIG. **8**A is provided for purposes of illustration only, as other systems may alter impedance values and similar systems may generate different impedance values depending upon medical conditions of patient **14**. As depicted, impedance data **170**A may cover testing over multiple stages. For example, first stage **172**A includes impedance data **170**A of an electrical signal across path **132** before a tug test (e.g., using tether **162**) while second stage **174**A includes impedance data **170**A of an electrical signal across path **132** during a tug test (e.g., using tether **162**).

[0161] As depicted, impedance data **170**A of IMD **16**A that defines non-fixation configuration **150**B may generally curve up and down between primary peaks **176**A and primary valleys **178**A. During first stage **172**A, impedance data **170**A may define relatively noisy slopes between primary peaks **176**A and primary valleys **178**A. For example, impedance data **170**A defines slopes with ledges or steps, slopes that change a direction of a curve, slopes that are substantially horizontal, or the like between primary peaks **176**A and primary valleys **178**A. Processing circuitry **120** may be configured to detect these relatively complex slopes as exceeding slope threshold **136** stored in memory **122**. As such, processing circuitry **120** may be configured to detect that first stage **172**A of impedance data **170**A indicates second non-fixation configuration **150**B.

[0162] Additionally, or alternatively, processing circuitry **120** may analyze second stage **174**A. Second stage data **174**A may indicate second non-fixation configuration **150**B with more clarity and repeatability than first stage data **172**A in some examples (e.g., due to the tug test highlighting potential deficiencies in the manner in which IMD **16**A is secured to tissue **142**), improving an ability of processing circuitry **120** detecting second non-fixation configuration **150**B. For example, processing circuitry **120** may detect bimodal signatures **180**A incorporated into impedance data **170**A during second stage **174**A of tug test. Bimodal signatures **180**A, as depicted and used herein, include more pronounced deviations in slopes between peaks **176**A and valleys **178**A than impedance data **170**A of first stage **172**A. For example, each of bimodal signatures **180**A may define secondary peak **182** and secondary valley **184** in between defining primary peak **176**A and primary valley **178**A. For example, as depicted, during second stage **174**A impedance data **170**A defines secondary peaks **182** around 225Ω and secondary valleys **184** around 215Ω in addition to defining primary peaks **176**A around 240Ω and primary valleys **178**A around 220Ω Processing circuitry **120** may be configured to detect these secondary peaks **182** and valleys **184** as bimodal signatures **180**A. As thusly detected, processing circuitry **120** may be configured to detect that impedance data **170**A indicates second non-fixation configuration **150**B.

[0163] FIG. **8**B is a chart of example impedance data **170**B as may be identified by impedance detection circuitry **126** and determined by processing circuitry **120** to indicate second fixation configuration **152**B. It is to be understood that impedance data **170**B provided in FIG. **8**B is provided for purposes of illustration only, as other systems may alter impedance values and similar systems may generate different impedance values depending upon medical conditions of patient **14**. As depicted, impedance data **170**B may cover testing over multiple stages. For example, first stage **172**B includes impedance data **170**B of an electrical signal across path **132** before a tug test (e.g., using tether **162**) while second stage **174**B includes impedance data **170**B of an electrical signal across path **132** during a tug test (e.g., using tether **162**).

[0164] As depicted, impedance data **170**B of IMD **16**A that defines second fixation configuration **152**B may generally curve up and down between primary peaks **176**B and primary valleys **178**B. However, as compared to impedance

data **170**A as detected by impedance detection circuitry **126** when IMD **16**A defined second non-fixation configuration **150**B, slopes between primary peaks **176**B and primary valleys **178**B are relatively smooth. For example, impedance data **170**B defines slopes that substantially avoid defining ledges or steps, changes of direction, substantially horizontal sections, or the like between primary peaks **176**B and primary valleys **178**B. Processing circuitry **120** may be configured to detect these relatively smooth slopes as within or otherwise satisfying slope threshold **136** stored in memory **122**. As such, processing circuitry **120** may be configured to detect that first stage **172**B of impedance data **170**B indicates second fixation configuration **152**B.

[0165] Additionally, or alternatively, processing circuitry **120** may analyze second stage **174**B. Impedance data of a second stage that is gathered during a tug test may indicate a possible second non-fixation configuration **150**B with more clarity and repeatability than impedance data gathered when no tug test is being executed. Thus, processing circuitry **120** may categorize impedance data **170**B as indicating second fixation configuration **152**B with a higher degree of confidence (e.g., a higher confidence score) when processing circuitry **120** analyzes impedance data **170**B of second stage **174**B. For example, processing circuitry **120** may analyze impedance data **170**B of second stage **174**B and identify that slopes between primary peaks **176**B and primary valleys **178**B are substantially smooth. In some examples, processing circuitry **120** may be configured to disregard (e.g., not consider) transition data **182** at an initial period of second stage **174**B where impedance data **170**B later defines slopes within slope threshold **136**. As a result of slopes of impedance data **170**B being within slope threshold **136** during first stage **172**A and second stage **172**B, processing circuitry **120** may identify impedance data **170**B as indicating second fixation configuration **152**B.

[0166] Additionally, or alternatively, processing circuitry **120** may analyze phase of the sets of impedance data **170**A, **170**B to determine whether or not the sets of impedance data **170**A, **170**B indicate second non-fixation configuration **150**B or second fixation configuration **152**B. FIGS. **9**A and **9**B are charts of example sets of phase data **190**A, **190**B as may be identified by processing circuitry **120** as indicating second non-fixation configuration **150**B, and second fixation configuration **152**B, respectively. For example, as discussed herein, each set of phase data **190**A, **190**B may be identified by identify an amount of lag between voltage and current from respective sets of impedance data **170**A, **170**B of FIGS. **8**A and **8**B. It is to be understood that phase data **190**A illustrated in FIG. **9**A and phase data **190**B illustrated in FIG. **9**B are both provided for purposes of illustration only, as other systems may capture slightly different phase values and similar systems may capture different phase values depending upon medical conditions of patient **14**. As depicted, both phase data **190**A and phase data **190**B may cover testing over multiple stages, similar to the charts of FIGS. **8**A and **8**B as discussed above (e.g., where phase data of first stages **172**A and **172**B is gathered prior to a tug test and phase data of second stages **174**A and **174**B is gathered during a tug test).

[0167] As depicted, phase data **190**A during first stage **172**A may fluctuate dramatically between a general high value (e.g., approximately 10°) and a general low value (e.g., approximately 9.3°). Outside of these approximate upper and lower thresholds, phase data **190**A may substantially avoid defining a repeating pattern. Put differently, phase data **190**A may avoid defining a relatively consistent max value (e.g., a phase value that is the same as other peak values within first stage **172**A, ±0.1°) or a relatively consistent minimum value (e.g., a phase value that is the same as other valley values within first stage **172**A, ±0.1°) in first stage **17**A. As a result of phase data **190**A defining a slope that fails to define relatively consistent maximum and minimum values, processing circuitry **120** may determine that phase data **190**A is outside of phase threshold **138**. Thus, processing circuitry **120** may determine that phase data **190**A indicates that IMD **16**A defines non-fixation configuration **150**B.

[0168] Additionally, or alternatively, processing circuitry **120** may analyze impedance data **190**A of second stage **174**A. Second stage data **174**A may indicate second non-fixation configuration **150**B with more clarity and repeatability than first stage data **172**A in some examples (e.g., due to the tug test highlighting potential deficiencies in the manner in which IMD **16**A is secured to tissue **142**), improving an ability of processing circuitry **120** detecting second non-fixation configuration **150**B. For example, processing circuitry **120** may detect bimodal signatures **180**B incorporated into phase data **190**A during second stage **174**A of tug test. Bimodal signatures **180**B may be substantially similar to bimodal signatures **180**A of impedance data **170**A. For example, each of bimodal signatures **180**B may define a secondary peak and a secondary valley in between defining a primary peak and a primary valley. Processing circuitry **120** may be configured to detect these secondary peaks and valleys as bimodal signatures **180**B. As thusly detected, processing circuitry **120** may be configured to detect that phase data **170**A indicates second non-fixation configuration **150**B.

[0169] As discussed herein, processing circuitry **120** may also analyze phase data and determine that phase data indicates that IMD **16**A defines second fixation configuration **152**B. For example, as depicted in FIG. **9**B, phase data **190**B of IMD **16**A that defines second fixation configuration **152**B may generally curve up and down between primary peaks **192** and primary valleys **194**. As depicted, phase values of primary peaks **192** and primary valleys **194** may both be substantially consistent (e.g., ±0.1°). Further, slopes between primary peaks **192** and primary valleys **194** are relatively smooth (e.g., such that phase data **170**B defines slopes that substantially avoid defining ledges, steps, changes of direction, substantially horizontal sections, or the like between primary peaks **192** and primary valleys **194**). Processing circuitry **120** may be configured to detect that these substantially consistent maximum and minimum values (and or these relatively smooth slopes) as being within or otherwise satisfying phase threshold **138** stored in memory **122**. As such, processing circuitry **120** may be configured to detect that first stage **172**B of phase data **190**B indicates second fixation configuration **152**B.

[0170] Additionally, or alternatively, processing circuitry **120** may analyze phase data **190**B of second stage **174**B. Phase data of a second stage that is gathered during a tug test may indicate a possible second non-fixation configuration **150**B with more repeatability than phase data gathered when no tug test is being executed. Thus, processing circuitry **120** may categorize phase data **190**B as indicating second fixation configuration **152**B with a higher degree of confidence (e.g., a higher confidence score) when processing circuitry

120 analyzes phase data 190B of second stage 174B. For example, processing circuitry 120 may analyze phase data 190B of second stage 174B and identify that slopes between primary peaks 192 and primary valleys 194 are substantially smooth, such that phase data 190B of second stage 174B does not define bimodal signatures 180B. In some examples, processing circuitry 120 may be configured to disregard (e.g., not consider) transition data 196 of phase data 190B at an initial period of second stage 174B where phase data 190B later defines slopes within phase threshold 138 without bimodal signatures 180B. As a result of slopes of phase data 190B being within phase threshold 138 during first stage 172A and second stage 172B without defining bimodal signatures 180B, processing circuitry 120 may identify phase data 190B as indicating second fixation configuration 152B.

[0171] As discussed, in some examples processing circuitry 120 may execute FFT techniques on impedance data 170 to identify FFT data 200A, 200B (collectively, "FFT data 200"). For example, FIG. 10A is a chart of example FFT data 200A created by processing circuitry 120 by executing FFT techniques on impedance data 170A (though it is to be understood that processing circuitry 120 may execute FFT techniques on other sets of impedance data in other examples). Processing circuitry 120 may identify FFT data 200A as indicating second non-fixation configuration 150B as described below. It is to be understood that FFT data 200A provided in FIG. 10A is provided for purposes of illustration only, as other systems may alter impedance values and similar systems may generate different impedance values depending upon medical conditions of patient 14. As depicted, processing circuitry 120 may only execute FFT techniques to identify FFT data 200A of impedance data 170 during second stage 174. Put differently, processing circuitry 120 may be configured to identify FFT data 200 that occurred while a clinician was executing a tug test. In other examples, processing circuitry 120 may identify more or less FFT data 200. For example, processing circuitry 120 may additionally identify FFT data 200 during first stage 172 which is subsequent to the deployment of IMD 16A but prior to the tug test.

[0172] Processing circuitry 120 may identify includes base frequency 202A and a plurality of harmonic frequencies 204A, 204B, 204C (collectively, "harmonic frequencies 204") of FFT data 200A. As discussed above, base frequency 202A may correspond to a heartbeat of patient 14. Processing circuitry 120 may determine that a ratio between one or more harmonic frequencies 204 and base frequency 202A does not satisfy FFT threshold 139. For example, FFT threshold 139 may include a ratio of 1:4 between base frequency 202A and a first harmonic (e.g., the harmonic frequency with the largest amplitude, which processing circuitry 120 may identify as harmonic frequency 204A). Processing circuitry 120 may identify that first harmonic frequency 204A has an amplitude that is larger than 25% of the amplitude of base frequency 202A as depicted in FIG. 10A, where first harmonic frequency 204A has an amplitude that is around 50% of base frequency 202A. In response to determining that first harmonic frequency 204A has an amplitude that is more than 25% the amplitude of base frequency 202A, processing circuitry 120 may cause indicating circuitry 128 to indicate second non-fixation configuration 150B on user interface 104 as described herein.

[0173] Additionally, or alternatively, FFT threshold 139 may include a ratio between an amplitude of base frequency 202A and a sum of a plurality of amplitudes of a plurality of harmonic frequencies 204, and processing circuitry 120 may identify if the ratio satisfies the FFT threshold 139. For example, FFT threshold 139 may include a 3:5 ratio between the amplitude of base frequency 202A and the sum of the amplitudes of the first three harmonic frequencies 204A, 204B, 204C. Processing circuitry 120 may identify that the sum of the amplitudes of the first three harmonic frequencies 204A, 204B, 204C is higher than 60% of the amplitude of base frequency 202A as depicted in FIG. 10A. In response to determining that the sum of the amplitudes of the first three harmonic frequencies 204A, 204B, 204C is greater than 60% of the amplitude of base frequency 202A, processing circuitry 120 may cause indicating circuitry 128 to indicate second non-fixation configuration 150B on user interface 104 as described herein.

[0174] Additionally, processing circuitry 120 may execute FFT techniques on impedance data 170 to determine that IMD 16A indicates second fixation configuration 152B. For example, FIG. 10B is a chart of example FFT data 200B created by processing circuitry 120 by executing FFT techniques on impedance data 170B (though it is to be understood that processing circuitry 120 may execute FFT techniques on other sets of impedance data in other examples as discussed above). As depicted, processing circuitry 120 may only execute FFT techniques to identify FFT data 200B of impedance data 170B during second stage 174B, though processing circuitry 120 may execute FFT techniques on other portions of impedance data 170 (e.g., such as during first stage 172 which is subsequent to the deployment of IMD 16A but prior to the tug test) in other examples.

[0175] Processing circuitry 120 may identify base frequency 202B and a plurality of harmonic frequencies 206A, 206B, 206C (collectively, "harmonic frequencies 206") of FFT data 200B. As discussed above, base frequency 202B may correspond to a heartbeat of patient 14. Processing circuitry 120 may determine that a ratio between one or more harmonic frequencies 206 and base frequency 202B satisfies FFT threshold 139. For example, FFT threshold 139 may include a ratio of 1:4 between base frequency 202B and a first harmonic (e.g., the harmonic frequency with the largest amplitude, which processing circuitry 120 may identify as harmonic frequency 206B). Processing circuitry 120 may identify that first harmonic frequency 206B has an amplitude that is smaller than 25% of the amplitude of base frequency 202B as depicted in FIG. 10B, where first harmonic frequency 206B has an amplitude that is around 20% of base frequency 202B. In response to determining that first harmonic frequency 206B has an amplitude that is less than 25% the amplitude of base frequency 202B, processing circuitry 120 may cause indicating circuitry 128 to indicate second fixation configuration 152B on user interface 104 as described herein.

[0176] Additionally, or alternatively, FFT threshold 139 may include a ratio between an amplitude of base frequency 202B and a sum of a plurality of amplitudes of a plurality of harmonic frequencies 206, and processing circuitry 120 may identify if the ratio satisfies the FFT threshold 139. For example, FFT threshold 139 may include a 1:2 ratio between the amplitude of base frequency 202B and the sum of the amplitudes of the first three harmonic frequencies 206A, 206B, 206C. Processing circuitry 120 may identify that the

sum of the amplitudes of the first three harmonic frequencies **206**A, **206**B, **206**C is lower than 50% of the amplitude of base frequency **202**B as depicted in FIG. **10**BA. In response to determining that the sum of the amplitudes of the first three harmonic frequencies **206**A, **206**B, **206**C is lower than 50% of the amplitude of base frequency **202**B, processing circuitry **120** may cause indicating circuitry **128** to indicate second fixation configuration **152**B on user interface **104** as described herein.

[0177] FIG. **11** depicts a flowchart of a method of delivering a medical device to a target site within a patient using a delivery device as described herein. FIG. **11** is discussed with reference to circuitry **94** of FIG. **3** as well as IMD **16**A and delivery device **50** of FIG. **2**A, but it is to be understood that the method of FIG. **11** may be completed using other delivery devices and circuitry described herein to deliver implantable medical devices in other examples. Processing circuitry **120** may receive a request to test fixation (**220**). This request may be received from a clinician accessing user interface **104**. In some examples, processing circuitry **120** may receive this request using telemetry techniques.

[0178] Processing circuitry **120** may cause signal generation circuitry **124** to delivery an electrical signal to path **132** between first electrode **90** and second electrode **92** (**222**). Path **132** may include both tissue and fluid of patient **14**. Signal generation circuitry **124** may deliver this electrical signal by providing a known (e.g., sinusoidal or pulse) voltage potential across electrodes **90**, **92**. Impedance detection circuitry **126** may detect impedance levels and processing circuitry **120** may identify a phase of the signal across electrodes **90**, **92** on the impedance (**224**). Identifying phase across path **132** may include identifying an amount that the voltage lags or leads current across path **132**. Processing circuitry **120** may verify whether or not this impedance satisfies (e.g., is over) impedance threshold **134** as stored in memory **122** (**226**). Where processing circuitry **120** determines that the impedance does not satisfy (e.g., is under) impedance threshold **134**, processing circuitry **120** may cause indicating circuitry **128** to provide an indication on user interface **104** of first non-fixation configuration **150**A (**228**). For example, where user interface **104** is an LED, indicating circuitry **128** may cause this LED to provide a red color. For another example, where user interface **104** is a screen of external device **18**, indicating circuitry **128** may cause user interface **104** screen of external device **18** to display a failure message. In certain examples, processing circuitry **120** may cause signal generation circuitry **124**, impedance detection circuitry **126**, and indicating circuitry **128** to continue this logical loop until, e.g., processing circuitry **120** receives a message (from a clinician) to stop testing for the first fixation configuration.

[0179] Conversely, in response to processing circuitry **120** determining that the impedance satisfies (e.g., is over) impedance threshold **134**, impedance detection circuitry **128** may additionally determine whether phase (as identified at **224**) satisfies (e.g., is over) phase threshold **133** (**230**). Where processing circuitry **120** determines that the phase does not satisfy (e.g., is under) phase threshold **133**, processing circuitry **120** may cause indicating circuitry **128** to provide an indication on user interface **104** of first non-fixation configuration **150**A (**228**). Alternatively, when processing circuitry **120** determines that both impedance satisfies impedance threshold **134** and phase satisfies phase threshold **133**, processing circuitry **120** may cause indicating circuitry **128** to indicate a successful first fixation configuration **152**A (**232**). A successful first fixation configuration **152** may relate to distal opening **78** of deployment bay **52** of delivery device **50** that deploys IMD **16**A being flush with a surface of tissue **142** and/or pressing into tissue **142** at target site **140**. In some examples, indicating circuitry **128** may continue providing an indication of first fixation configuration **152**A for as long as processing circuitry **120** continues detecting that an impedance of an electrical signal across path **132** is over impedance threshold **134** (which is to say that step **232** may naturally return to step **222** unless an affirmative input from a clinician is received that overrides this return).

[0180] In some examples, circuitry **94** may further test if IMD **16**A defines second fixation configuration. In such examples, processing circuitry **120** may cause signal generation circuitry **124** to deliver an electrical signal to path **132** between first electrode **90** on distal tip **96** of IMD **16**A and second electrode **92** (**234**). Impedance detection circuitry **126** may identify an impedance of this signal, with which processing circuitry **120** may identify the phase of the signal (**236**). For example, processing circuitry **120** may determine a phase of heart **12** by identifying an amount that voltage of the signal across path **132** leads or lags a current. Processing circuitry **120** may determine whether the impedance is noisy (**238**). Processing circuitry **120** may determine that the impedance of the signal is noisy if the impedance fails to satisfy slope threshold **136** or if the impedance includes bimodal signatures **137** as stored in memory **122**. Where the impedance waveform fails to satisfy slope threshold **136** and/or includes bimodal signatures **137**, processing circuitry **120** may cause indicating circuitry **128** to provide second non-fixation configuration **150**B message to user interface **104** (**240**). In some examples, processing circuitry **120** may cause signal generation circuitry **124** to delivery an electrical signal to path **132** to test for first fixation configuration (**222**) in response to determining that impedance indicates second non-fixation configuration **150**B.

[0181] Where the impedance waveform is stable such that the impedance waveform satisfies slope threshold **136** and does not define bimodal signatures **137**, processing circuitry **120** may determine whether a phase (as identified in **236**) satisfies phase threshold **138** (**242**). Processing circuitry **120** may determine that the phase does not satisfy phase threshold **138** as a result of peaks and valleys of phase being inconsistent, and/or as a result of phase include bimodal signatures **137**. As a result of a phase of the electrical signal failing phase threshold **138**, processing circuitry **120** may cause indicating circuitry **128** to provide second non-fixation configuration **150**B message to user interface **104** (**240**). Similar to above, in some examples, processing circuitry **120** may cause signal generation circuitry **124** to delivery an electrical signal to path **132** to test for first fixation configuration (**222**) in response to determining that impedance indicates second non-fixation configuration **150**B (e.g., in order for deployment bay **52** to be reoriented by tissue to redeploy IMD **16**A).

[0182] If processing circuitry **120** determines that phase of the electrical signal satisfies phase threshold **138** and/or does not define bimodal signatures **137**, processing circuitry **120** may cause indicating circuitry **128** to provide indication of second fixation configuration **152**B (**244**). Second fixation configuration **152**B may include IMD **16**A being secured to tissue **142** according to a predetermined manner. For

example, second fixation configuration **152**B may include distal electrode **90** of IMD **16**A pressing into tissue **142** securely and uniformly and with at least a threshold amount of force. In some examples, processing circuitry **120** may be configured to chronically determine whether IMD **16**A defines second fixation configuration **152**B. For example, as indicated in the flowchart of FIG. **11**, processing circuitry **120** may cause signal generation circuitry **124** to continue sending an electrical signal across path **132** such that processing circuitry **120** may continually identify if IMD **16**A continually defines second fixation configuration **152**B. Processing circuitry **120** may be configured to thusly verify whether or not IMD **16**A defines second fixation configuration **152**B on a regular schedule, such as once an hour, once a day, once a week, or the like. Processing circuitry **120** may be configured to cause indicating circuitry **128** to send a message (e.g., to external device **18**) if IMD **16**A is still defining second fixation configuration **152**B, or whether IMD **16**A has shifted such IMD **16**A has started defining second non-fixation configuration **150**B.

[0183] FIG. **12** depicts a flowchart of a method of delivering a medical device to a target site within a patient using a delivery device as described herein. FIG. **12** is discussed with reference to delivery device **50** of FIGS. **2**A-**7** as well as IMD **16**A of FIG. **1**A, but it is to be understood that the method of FIG. **12** may be completed using the other delivery device described herein to delivery any insertable or implantable medical device in other examples. A clinician may navigate delivery device **50** to target site **140** within patient **14** (**250**). For example, a clinician may navigate deployment bay **52** of delivery device **50** to right atrium **20** of heart **12** of patient **14** (as depicted in FIG. **1**A). The clinician may navigate delivery device **50** to target site **140** after inserting delivery device **50** into an introducer sheath inserted into patient **14**. The clinician may navigate delivery device **50** to target site **140** using one or more deflection members **102** as deflected using a steering or deflecting mechanism of hub **56**. Once the clinician has navigated deployment bay **52** to target site **140**, the clinician may press deployment bay **52** against the target site **140**. The clinician may use radiopaque elements of delivery device **50** (e.g., such as electrodes **90**, **92**) to navigate the deployment bay **52** to target site **140** using fluoroscopy techniques.

[0184] Once the clinician has arranged the deployment bay **52** at the target site **140**, the clinician may provide an input to generate a first signal across a path between first electrode **90** within recess **74** of deployment bay **52** and second electrode **90** outside of recess **74** of deployment bay **52** (**252**). The clinician may check to see whether or not circuitry **94** indicates that deployment bay **52** defines first fixation configuration **152**A (**254**). The clinician may use user interface **104** to determine whether or not circuitry **94** indicates that deployment bay **52** defines first fixation configuration **152**A. Where the user interface **104** does not indicate first fixation configuration **152**A (e.g., but instead indicates first non-fixation configuration **150**A), the clinician may reposition deployment bay **52** at target site **140** (**256**).

[0185] Once the clinician sees (as indicated by user interface **104**) that circuitry **94** indicates that deployment bay **52** defines first fixation configuration **152**A, the clinician may deploy IMD **16**A at target site **140** (**258**). Deploying IMD **16**A may include using deployment mechanism **66** to distally push IMD **16**A relative to deployment bay **52** until fixation means **82** engage tissue **142**. Once IMD **16**A is deployed, the clinician provides an input to circuitry **94** to provide an input to generate a second signal to path **132** between first electrode **90** on distal tip **96** of IMD **16**A and second electrode **92** that is proximal to distal tip **96** (**260**). The clinician may provide the input to generate the second signal in the same manner as the clinician provided the input for the first signal. Upon providing the input, the clinician may execute a tug test on IMD **16**A (**262**). For example, the clinician may tug on tether **262** of delivery device **50** subsequent to providing the input to circuitry **94** to generate the second signal and therein verify a fixation of IMD **16**A.

[0186] The clinician may determine whether IMD **16**A defines second fixation configuration **152**B (**264**). For example, the clinician may use user interface **104** to see if circuitry **94** indicates that IMD **16**A defines second fixation configuration **152**B. Where circuitry **94** indicates that IMD **16**B does not define second fixation configuration **152**B (e.g., but instead defines second non-fixation configuration **150**B), the clinician may retract IMD **16**A into deployment bay **52** (**266**). For example, the clinician may use tether **162** as engaged with proximal catch **114** of IMD **16**A to retract IMD **16**A into deployment bay **52**. In some examples, in response to retracting IMD **16**A, the clinician may look to reposition deployment bay **52** into first fixation configuration **152**A by providing an input to generate the first signal again (**252**).

[0187] In other examples, the clinician may identify that user interface **104** indicates that IMD **16**A defines second fixation configuration **152**B. Where the clinician identifies that circuitry **94** indicates that IMD **16**A defines second fixation configuration **152**B, the clinician may release IMD **16**A (e.g., by cutting tether **162**) (**268**). Once IMD **16**A is deployed and fully release, the clinician may retract delivery device **50** out of patient **14** (**270**). The clinician may withdraw delivery device **50** out of introducer sheath through which delivery device **50** was inserted.

[0188] This disclosure is primary directed to medical delivery devices that use an impedance between electrodes to verify when deployment bays that contain implantable devices and/or the devices themselves define various fixation configurations that indicate that the implantable devices either are aligned to be or are currently properly secured to a target site in a heart. However, one or more aspects of this disclosure may also be applicable to delivering other insertable or implantable medical devices to other areas of a patient. For one example, as discussed herein, aspects of this disclosure may be applicable to delivering a lead that includes distal fixation elements to a target site within a patient. Further, aspects of this disclosure may be applicable to delivering a lead to a spinal cord or another organ of a patient. Other applications for aspects of this disclosure would also be understood by one of ordinary skill in the art.

[0189] Various examples have been described. These and other examples are within the scope of the following claims.

1. An implantable medical device delivery system comprising:

an elongated member configured to navigate an intravascular system of a patient;

a deployment bay connected to a distal portion of the elongated member and configured to house at least a portion of an implantable medical device (IMD), the deployment bay defining a distal opening configured for deployment of the IMD out of the deployment bay at a target site in a patient;

signal generation circuitry configured to deliver an electrical signal to a path between a first electrode located inside of the deployment bay and a second electrode through at least one of a fluid or tissue of the patient; and

processing circuitry configured to:

determine an impedance of the path based on the signal; and

generate an output that indicates when an impedance of the path indicates that at least one of the IMD or the distal opening is in a fixation configuration relative to the target site of the patient via a user interface.

2. The medical delivery system of claim **1**, wherein the fixation configuration includes a first fixation configuration wherein the distal opening of the deployment bay is substantially flush against a tissue of the target site.

3. The medical delivery system of claim **2**, wherein the deployment bay is pressed against the tissue with a threshold amount of force in the first fixation configuration.

4. The medical delivery system of claim **2**, further comprising the IMD, wherein the first and second electrodes are first and second electrodes of the IMD

5. The medical delivery system of claim **4**, wherein the deployment bay defines one or more holes that extend radially in through the deployment bay to expose the second electrode to fluids of the patient.

6. The medical delivery system of claim **5**, further comprising one or more ribs that extend radially in from an inner surface of the deployment bay to engage the housing of the IMD, wherein the one or more holes extend radially in through the one or more ribs.

7. The medical delivery system of claim **2**, wherein the first electrode is secured to an inner surface of the deployment bay.

8. The medical delivery system of claim **2**, wherein the second electrode is secured to an outer surface of the deployment bay or an outer surface of the elongated member.

9. The medical delivery system of claim **1**, further comprising the IMD, wherein the first and second electrodes are first and second electrodes of the IMD and the IMD comprises one or more fixation elements, and wherein the fixation configuration includes a second fixation configuration wherein a threshold amount of the one or more fixation elements of the IMD are secured to the tissue of the target site.

10. The medical delivery system of claim **1**, wherein user interface comprises a display of an external device, the system further comprising telemetry circuitry, wherein the processing circuitry is configured to use the telemetry circuitry to cause the display of the external device to indicate when the impedance of the path indicates that at least one of the IMD or the distal opening is in the fixation configuration relative to the target site of the patient.

11. The medical delivery system of claim **1**, wherein the user interface is located adjacent a proximal portion of the elongated member and is electrically coupled to the processing circuitry.

12. The medical delivery system of claim **1**, wherein the target site is a wall of an atrium of the patient.

13. A system for using an implantable medical device delivery system to deliver an implantable medical device to tissue of a patient, the system comprising:

signal generation circuitry configured to deliver an electrical signal to a path between a first electrode and a second electrode through at least one of a fluid or the tissue of the patient; and

processing circuitry configured to:

determine an impedance of the path based on the signal;

determine whether the impedance of the path indicates at least one of a first fixation configuration where a distal portion of the implantable medical device delivery system is substantially flush with tissue of a target site or a second fixation configuration where one or more fixation elements of the implantable medical device satisfy a fixation threshold to the tissue of the patient; and

provide an indication when the impedance of the path indicates at least one of the first fixation configuration or the second fixation configuration.

14. The system of claim **13**, where the processing circuitry is configured to determine that the impedance of the path indicates that the first fixation configuration when the impedance is over a threshold impedance.

15. The system of claim **13**, where the processing circuitry is configured to determine that the impedance of the path indicates that the first fixation configuration by identifying that a phase waveform is above a threshold.

16. The system of claim **13**, wherein the processing circuitry is configured to determine if the impedance indicates at least one of the first or second fixation configuration by at least determining a first derivative amplitude of the impedance.

17. The system of claim **13**, wherein the processing circuitry is configured to determine whether the impedance of the path indicates a second fixation configuration by being configured to:

determine an amount of noise of a waveform of the impedance; and

determine whether the amount of noise satisfies a noise threshold.

18. The system of claim **17**, wherein the noise includes bimodal signatures and the processing circuitry is configured to determine that the waveform of the impedance indicates the second fixation configuration based on identification of the bimodal signatures.

19. The system of claim **18**, wherein the processing circuitry is configured to determine the amount of noise by at least identifying frequency components of the signal.

20. The system of claim **13**, wherein the system is integrated into the implantable medical device delivery system.

21. The system of claim **13**, wherein the system is integrated into the implantable medical device.

22. An implantable medical device (IMD) comprising:

a housing configured to be secured to a target site in a patient via one or more fixation elements extending distally from a distal tip of the housing;

a first electrode secured to the distal tip of the housing;

a second electrode secured to an outer surface of a proximal portion of the housing;

signal generation circuitry configured to deliver an electrical signal to a path between the first electrode and the second electrode through at least one of a fluid or tissue of the patient; and

processing circuitry configured to:

determine an impedance of the path based on the signal; and

generate an output that indicates when an impedance of the path indicates that the IMD is in a fixation configuration relative to the target site of the patient via a user interface.

23. The IMD of claim **22**, wherein:

the fixation configuration includes a threshold number of the fixation elements of the IMD being secured to the tissue of the target site;

the processing circuitry is configured to determine an amount of noise of a waveform of the impedance and determine whether the waveform indicates that the IMD is in the fixation configuration based on the amount of noise.

24. The IMD of claim **22**, wherein the noise includes bimodal signatures and the processing circuitry is configured to determine that the waveform of the impedance indicates the fixation configuration when the waveform does not define the bimodal signatures.

25. The IMD of claim **22**, wherein the processing circuitry is configured to determine the amount of noise by at least one of:

identifying frequency components above a threshold; or

decomposition of the impedance signal via frequency components.

26. The IMD of claim **22**, wherein the IMD is a leadless pacemaker.

27. The IMD of claim **22**, wherein the one or more fixation elements comprise one or more fixation tines.

28. The IMD of claim **22**, further comprising telemetry circuitry, wherein the processing circuitry generates the output via the telemetry circuitry.

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